NATIONAL RADIO ASTRONOMY OBSERVATORY

Engineering Memo. No. 147

CALIBRATION OF THE 140-FOOT TELESCOPE AT 3245 MHz, 4990 MHz, and 10500 MHz

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October 1981

I. Introduction

As reported in Engineering Memo No. 146, the shift in the position of the Sterling mount of the 140-foot telescope in April 1980 corrected the east-west asymmetry only for the position angle (292°5) then in use. When a new receiver was installed at a position angle of 22°5, the asymmetry reappeared but with a peak at 2^h West rather than East. At the end of June 1981 both the subreflector and Sterling mount were repositioned to correct the asymmetry. I then had three calibration runs between 25 July and 8 September 1981 to re-determine the pointing corrections and measure gain curves at 3245, 4990, and 10500 MHz.

During the run, the total pointing offsets were measured for each source observation using the verb POINT, the pointing corrections were applied, and the antenna temperature was measured using the OFFON verb with 3 off-on's. The 11 pointing coefficients for each run were then determined following the procedure outlined by Sebastian von Hoerner in Engineering Division Internal Report No. 102 on the "140-Foot Pointing Program, and Thermal Shielding of Shaft and Yoke" (except I will identify the coefficients as C_i's instead of P_i's). The gain curve for each run was fit with spherical harmonics (see also Engineering Memo No. 146):

$$Y_{00} = 1$$

$$Y_{10} = \cos\theta$$

$$Y_{11}^{e} = \sin\theta\cos\phi$$

$$Y_{11}^{o} = \sin\theta\sin\phi,$$

where θ = hour angle and $\phi = 90° - \delta$.

No higher-order terms were necessary.

II. Calibration at 3245 MHz

The observations at 3245 MHz between 26-28 July 1981 were made using the dual-channel 9-cm receiver with an on-axis feed with orthogonal linear polarizations (feed 1 was north-south and feed 2, east-west). In the analysis I concluded that the cables to the computer were switched because otherwise the observations of the strongly polarized sources did not make sense and because the observed temperature scales differed by ∿ 15%.

The gain calibrators used are listed in Table 1. Most of the flux densities were interpolated from the observations catalogued by Kühr et al. (1979, 1981). Several were determined from the present observations.

The pointing coefficients determined using all the data are listed in Table 4; Figures 1-6 show the sky coverage, the calculated right ascension and declination corrections and their errors, and the total pointing error. Table 4 also lists the pointing coefficients determined from the night-time data only. There is no significant difference between the two fits, which indicates that the thermal shielding is working. Although the rms error is slightly smaller for the nighttime fit, that using all the data is considerably better determined. No data were available above 72° because of a software problem in the 140-foot control program.

The most satisfactory gain curves were constants; the average observed gains for the properly identified feeds are given in Table 5; they correspond to an aperture efficiency of ∿ 49%. A receiver problem caused both channels to give high antenna temperatures (by 50-100%) at low elevations; these points have been excluded from the fit.

III. Calibration at 4990 MHz

The observations at 4990 MHz between 30 August and 2 September 1981 used the upconverter/maser receiver with a left-circularly polarized feed. The calibrators used are listed in Table 2. Most flux densities are from the catalogues of Kühr et al. (1979, 1981) and from Pauliny-Toth and Kellermann (1968); three were measured with the VLA and eight were determined from these observations.

The pointing coefficients determined using all the data are listed in Table 4 (those determined using only the nighttime data are also shown). Figures 7-12 show the sky coverage and the calculated pointing corrections and errors. Again there is no significant difference between the two fits. During these observations the offset to the subreflector was applied with the wrong sign, so that the subreflector was offset by ∿ 1-1/4 inches from the proper position, causing changes in C_1 and C_6.

The most satisfactory gain curve was that fit with terms with $\ell \leq 1$; the parameters are given in Table 5 and the sky coverage and the gain curve and its error are shown in Figures 13-15. The peak gain is clearly offset at h = $1^h.0$, $\delta = 19°$, but this is an improvement over December 1980 at 10650 MHz when the peak occurred at h = $1^h.9$, $\delta = 27°$. The gain curve is well determined; the maximum formal error is less than 1%. The range of variation is about 10%, but the absolute temperature scale must be > 20% low because the peak gain corresponds to an aperture efficiency of 40%, which should be compared to the ∿ 60% reported by Pauliny-Toth and Kellermann (1968).

IV. Calibration at 10500 MHz

The observations 10500 MHz between 6-8 September 1981 used the upconverter/maser receiver with a left-circularly polarized feed. The calibrators used are listed in Table 3. Most of the flux densities were measured by Seielstad (1981) using the Owens Valley 130-foot telescope; others were obtained by Baars et al. (1977) and Kühr et al. (1981); and four were measured during the present observations. The subreflector offset was corrected after the run at 4990 MHz.

The pointing coefficients determined from all the data are listed in Table 4; too few nighttime observations were available for a fit. The sky coverage and the calculated pointing corrections and errors are shown in Figures 16-21. The offsets C_1 and C_6 are now nearly the same as measured at 3245 MHz, which indicates that the subreflector is close to center.

Again the fit with terms with $\ell \leq 1$ produced the most satisfactory gain curve. I was also using a preliminary version of a tipping procedure, and the gain curve determined using the observations corrected for atmospheric attenuation is given in Table 5, too. The sky coverage and the uncorrected gain curve and its error are shown in Figure 22-24; the corrected gain curve and its error are shown in Figures 25-26. The corrected gain curve is appropriate for comparison with lower frequencies and the study of the true performance of the telescope. The peak gain at 10500 MHz occurs at $h = 0^h.9$, $\delta = 19°$, almost exactly same as observed at 4990 MHz. The two gain curves are well determined; the maximum formal error in either is less than 2-1/4%. The peak corrected gain corresponds to an aperture efficiency of $\sim$ 49%, and the range of variation is 30%.

V. Summary

1. The pointing curves have been redetermined for both prime-focus and Cassegrain receivers after the most recent adjustments of the Sterling

mount and subreflector. Since the above observations were taken, repairs to the backup structure of the subreflector have caused changes in the pointing. In the future, if no reliable means to align the subreflector to better than 0.01 inches (corresponding to a pointing offset of 25") is found, the Cassegrain pointing curves may have to be redetermined after every modification or repair to the subreflector. Also separate pointing curves may be needed for each position of the subreflector once the second upconverter/maser receiver and beam splitter are installed.

2. No significant day-night effect on the pointing was seen during these observations.

3. In all cases the rms error in declination is very good (∿ 10") and the declination pointing is well behaved. The rms error in right ascension is twice as large (∿ 20") and the behavior sometimes seems non-random, as if the pointing equation used does not describe the pointing; and also I have not measured values of C_9, C_{10} and C_{11} that differed significantly from zero. I think that further analysis of the right ascension pointing is necessary.

4. The value of the noise tube during the observations at 4990 MHz was low by 25-30%. VLBI observers have reported problems with the noise tube values at 10650 MHz. Accurate noise tube values are essential at high frequencies because (as I did at 10500 MHz) the observer will often use tipping scans to measure the zenith attenuation τ to use in calibrating his observations; the receiver and ambient temperature scales should be within a few percent for an accurate determination of τ.

5. The correction for atmospheric attenuation worked very well at 10500 MHz. I hope an automatic version of the tipping procedure is implemented.

6. The observations at 4990 MHz and the corrected observations at 10500 MHz show that even after the most recent adjustments, the peak gain

still does not occur on the meridian. Both show the peak gain occurring at $h = 0^h.9-1^h.0$, $\delta = 19°$. The current behavior is better than that seen in 10650 MHz in December 1980 (the minimum gain is $\sim$ 8% higher) but the desired symmetry has not been achieved.

7. Three days of observing are necessary to calibrate the pointing and gain of the 140-foot telescope at 5 GHz and lower frequencies, particularly to study day-night effects on the pointing and to get complete coverage below $\delta = 20°$ for the pointing observations and for measuring the gain at $\sim$ 5 GHz. Also the software problems that limit the use of the verb POINT at high declinations should be fixed.

8. At high frequencies (>10 GHz), a minimum of 3 days and probably 4 days are needed to calibrate the telescope. The additional time is needed because of the time used for the tipping observations. At 10 GHz low-frequency nonvariable calibrators like 3C123 and 3C295 that are still strong can be used in addition to the high-frequency variable sources already used. The biggest problem is obtaining nearly simultaneous measurements of the flux densities of the variable sources from another telescope, whether at Owens Valley, Haystack, Bonn, or the VLA.

References

Baars, J. W. M., Genzel, R., Pauliny-Toth, I. I. K., and Witzel, A. 1977, Astr. Ap. 61, 99.

Kühr, H., Naubert, U., Pauliny-Toth, I. I. K., and Witzel, A. 1979, MPIfR Reprint No. 55.

Kühr, H., Witzel, A., Pauliny-Toth, I. I. K. and Nauber, U. 1981, submitted to Astr. Ap. Suppl.

Pauliny-Toth, I. I. K., and Kellermann, K. I. 1968, A. J. 73, 953.

Seielstad, G. 1981, private communication.

Table 1. Gain Calibrators at 3245 MHz

CTA 21	4.53	Kühr
DA251	7.10	7/81
N7027	4.26	7/81
0212+735	2.08	7/81
0237-233	4.59	Kühr
0428+205	2.94	Kühr
0531+194	3.63	Kühr
1151-348	3.96	Kühr
1245-197	3.41	Kühr
1345+125	3.53	Kühr
1938-155	3.78	7/81
2128+048	2.72	Kühr
2203-188	4.89	Kühr
3C123	24.28	Baars et al. 1977
3C147	11.67	Baars et al. 1977
3C161	9.77	Baars et al. 1977
3C17	3.63	Kühr
3C18	2.59	7/81
3C20	5.69	Kühr
3C218	20.14	Kühr
3C231	4.69	Kühr
3C237	3.07	Kühr
3C268.1	3.51	Kühr
3C286	9.47	Baars et al. 1977
3C287	4.15	Kühr
3C295	10.14	Baars et al. 1977
3C309.1	4.00	7/81
3C330	3.21	Kühr
3C388	2.73	Kühr
3C401	2.32	Kühr
3C433	5.71	Kühr
3C438	2.70	7/81
3C48	7.82	Baars et al. 1977

Table 2. Gain Calibrators at 4990 MHz

CTA21	2.86	Kühr
DA251	5.49	8/81
N7027	5.75	Pauliny-Toth and Kellermann 1968
0022-423	1.82	Kühr
0212+735	2.31	VLA 21/6/81
0237-233	3.38	8/81
0428+205	2.31	Kühr
0454+844	1.01	VLA 21/6/81
1151-348	2.65	VLA 20/11/80
1215-457	2.05	Kühr
1245-197	2.48	8/81
1345+125	3.01	Kühr
1358+624	1.79	Kühr
2128+048	2.09	8/81
2203-188	4.32	8/81
2342+821	1.33	Kühr
3C123	16.20	Kühr
3C147	7.78	8/81
3C161	6.73	Pauliny-Toth and Kellermann 1968
3C17	2.72	Kühr
3C18	1.73	Kühr
3C20	4.24	Kühr
3C231	3.67	Kühr
3C237	2.01	Pauliny-Toth and Kellermann 1968
3C268.1	2.67	Kühr
3C274	65.75 (peak)	Pauliny-Toth and Kellermann 1968
3C280	1.76	8/81
3C286	7.48	Kühr
3C287	3.26	Kühr
3C295	6.60	Kühr
3C309.1	3.39	Kühr
3C330	2.38	Kühr
3C433	3.74	Kühr
3C438	1.58	Kühr
3C48	5.59	8/81

Table 3. Calibrators at 10500 MHz

MONR2	7.14	OVRO 3/81
N7027	6.45	Baars et al. 1977
0106+013	4.94	OVRO 9/81
0316+413	64.32	9/81
0355+508	8.54	9/81
0420-014	5.22	OVRO 9/81
0454+844	0.99	OVRO 9/81
0528+134	4.57	OVRO 9/81
0537-441	6.34	9/81
0552+398	3.54	9/81
0826-373	2.91	OVRO 9/81
0836+710	2.39	OVRO 9/81
0851+202	4.91	OVRO 9/81
0923+392	6.08	OVRO 9/81
1228+126	38.09	Baars et al. 1977
1328+307	4.46	Baars et al. 1977
1334-127	3.54	OVRO 9/81
1418+546	1.80	OVRO 9/81
1451-375	1.37	OVRO 9/81
1510-089	2.23	OVRO 9/81
1642+690	1.86	OVRO 9/81
1730-130	4.57	OVRO 9/81
1921-293	9.28	OVRO 9/81
1928+738	3.02	Kühr
2005+403	4.37	OVRO 9/81
2134+004	8.04	OVRO 9/81
2200+420	4.58	OVRO 9/81
2251+158	20.16	OVRO 9/81

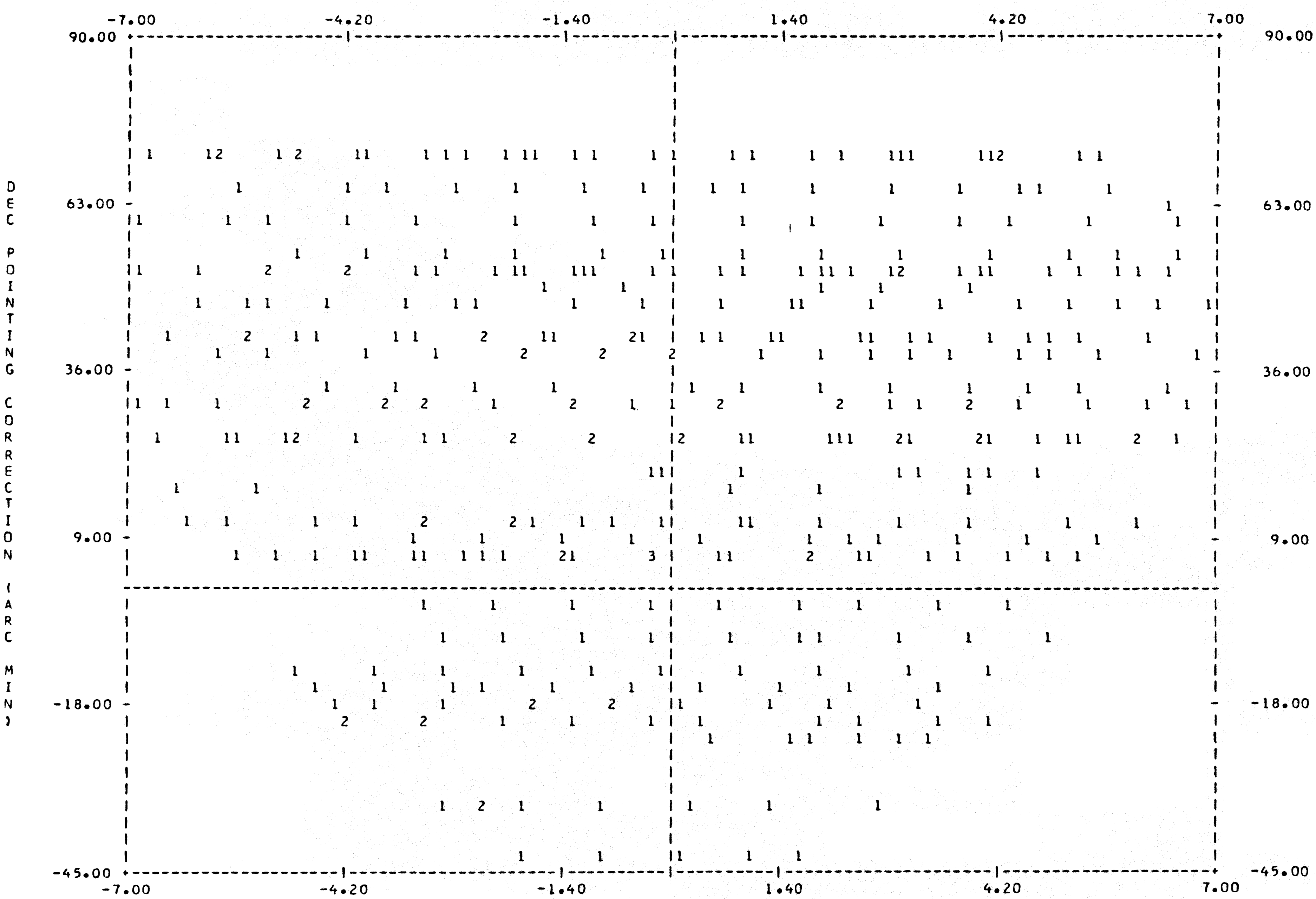
Table 4. Pointing Coefficients

	3245 MHz		4990 MHz		10500 MHz
	All	Night	All	Night	All
Number of Points	400	172	353	139	182
RA RMS/Point	18".2	18".2	20".7	17".4	22".4
Dec RMS/Point	11".9	9".3	11".0	9".0	10.8"
C_1	2'.14±0'.04	2'.02±0'.07	5'.83±0'.05	5'.72±0'.07	1'.78±0'.07
C_2	-0.51 0.03	-0.51 0.04	-0.45 0.03	-0.46 0.04	-0.41 0.04
C_3	-2.22 0.06	-2.15 0.09	-2.03 0.06	-1.95 0.08	-1.98 0.09
C_4	0.86 0.05	0.86 0.08	0.63 0.06	0.70 0.09	0.58 0.09
C_5	0.98 0.01	1.00 0.02	0.97 0.02	1.02 0.02	0.99 0.02
C_6	-1.65 0.13	-1.45 0.21	-5.16 0.13	-5.51 0.20	-2.07 0.17
C_7	-0.47 0.07	-0.48 0.10	-0.29 0.08	-0.20 0.10	-0.56 0.10
C_8	1.16 0.13	0.95 0.23	1.45 0.13	1.80 0.20	0.52 0.18
C_9	-0.15 0.21	-0.41 0.38	-0.62 0.23	-0.35 0.40	-0.38 0.31
C_{10}	-0.30 0.12	-0.33 0.19	-0.15 0.14	-0.45 0.24	-0.15 0.20
C_{11}	0.04 0.21	0.32 0.38	-0.16 0.22	-0.36 0.37	-0.37 0.29

Table 5. Parameters of Gain Curves

Frequency		Number of Points	RMS/Point	C_{00}	C_{10}	C_{11}^{e}	C_{11}^{o}
3245 MHz	Feed 1	339	0.0079 K/Jy	$(2.611\pm0.004)\times10^{-1}$K/Jy			
	Feed 2	339	0.0088	(2.468 ± 0.005)			
4990 MHz		261	0.0054	(1.900 ± 0.010)	$(0.060\pm0.010)\times10^{-1}$K/Jy	$(0.170\pm0.013)\times10^{-1}$K/Jy	$(0.046\pm0.007)\times10^{-1}$K/Jy
10500 MHz	Uncorrected	184	0.0136	(1.721 ± 0.027)	(0.327 ± 0.027)	(0.681 ± 0.039)	(0.107 ± 0.018)
	Corrected	184	0.0147	(1.933 ± 0.030)	(0.193 ± 0.030)	(0.549 ± 0.042)	(0.120 ± 0.020)

SKY COVERAGE



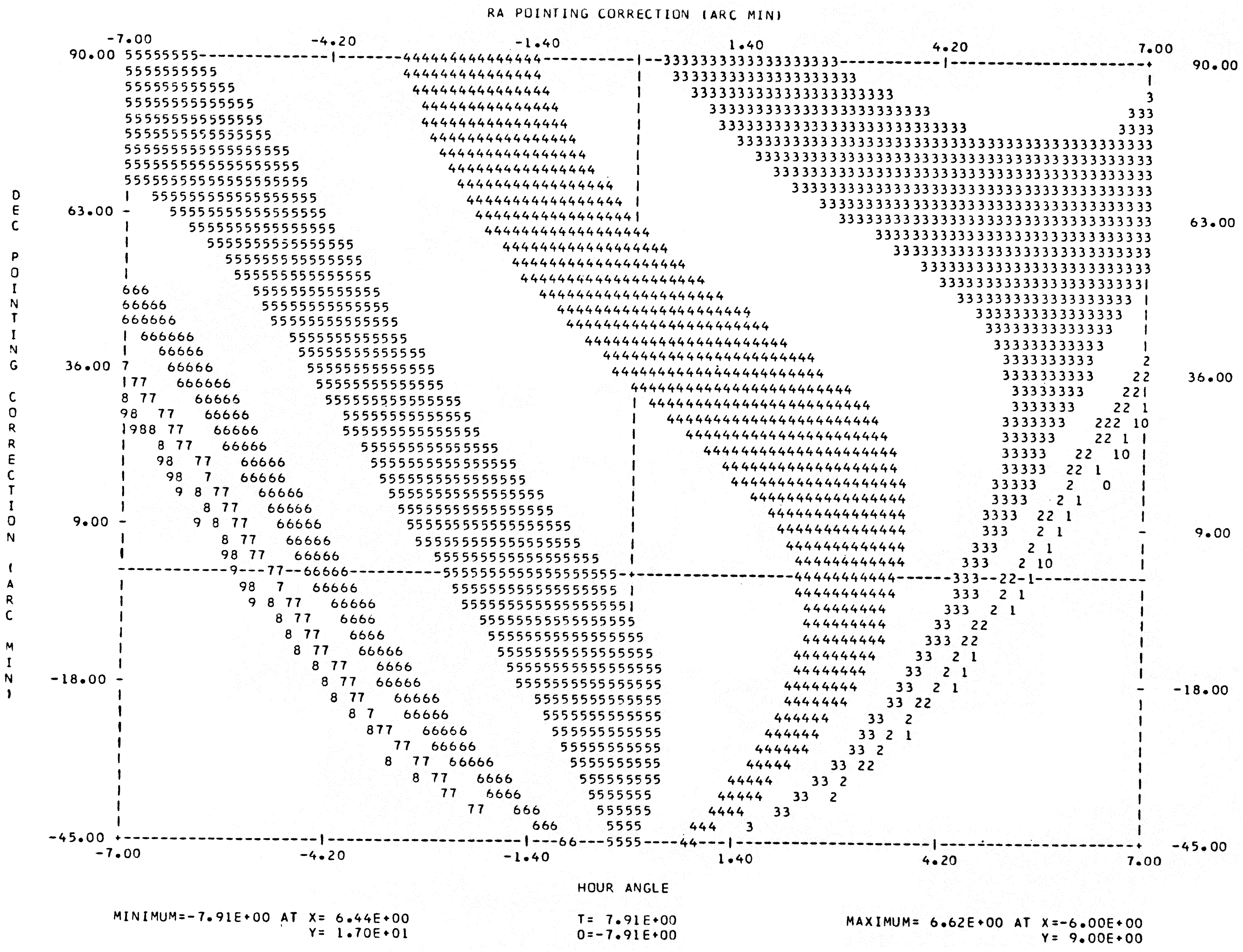
HOUR ANGLE

MINIMUM= 0.00E+00 AT X= 0.00E+00
Y= 0.00E+00

T= 1.00E+01
0= 0.00E+00

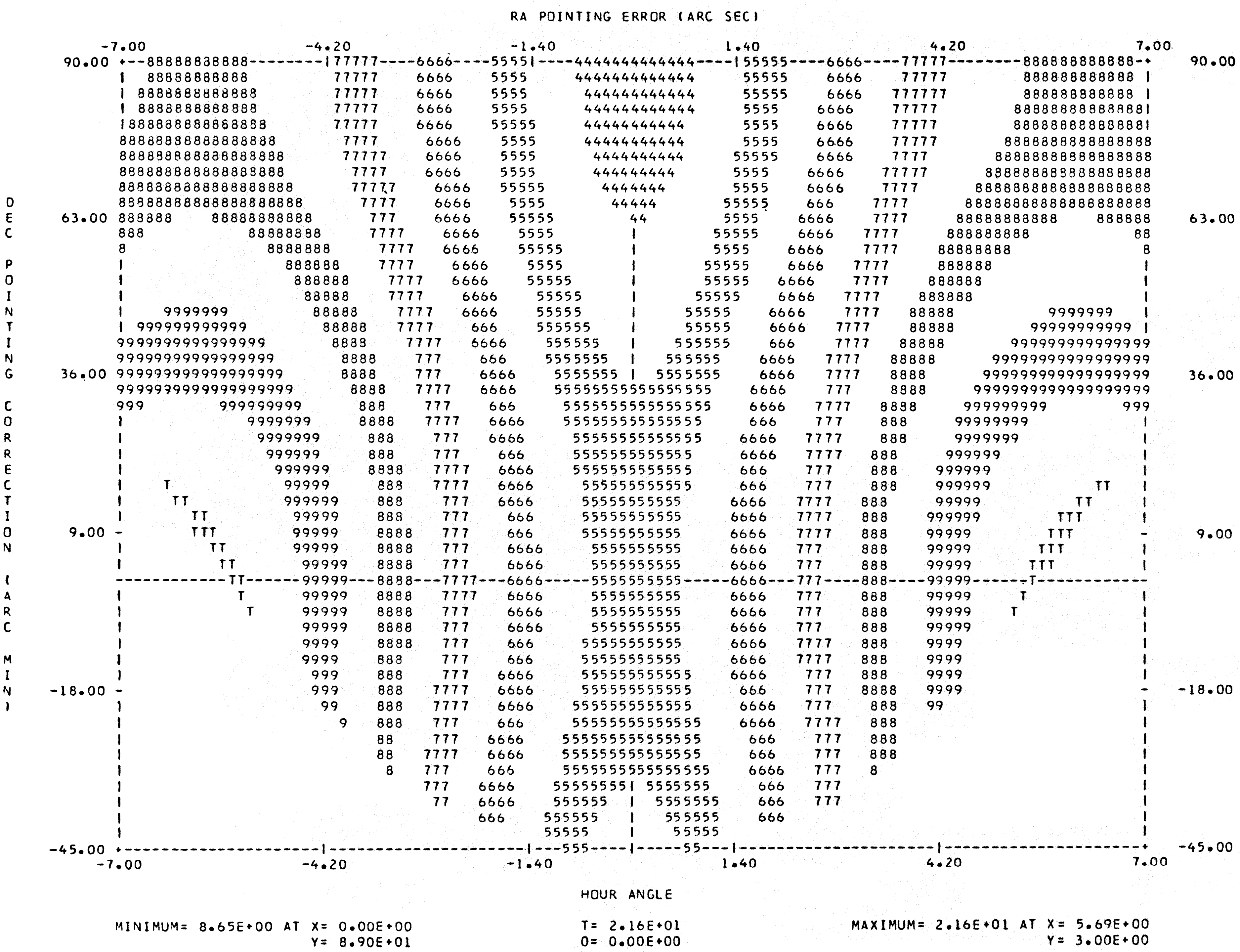
MAXIMUM= 0.00E+00 AT X= 0.00E+00
Y= 0.00E+00

Figure 1



RA POINTING CORRECTION (ARC MIN)
-7.00
-4.20
-1.40
1.40
4.20
7.00
90.00
63.00
36.00
9.00
-18.00
-45.00
DEC POINTING CORRECTION (ARC MIN)
HOUR ANGLE
MINIMUM=-7.91E+00 AT X= 6.44E+00
Y= 1.70E+01
T= 7.91E+00
0=-7.91E+00
MAXIMUM= 6.62E+00 AT X=-6.00E+00
Y= 9.00E+00

Figure 2.


RA POINTING ERROR (ARC SEC)
DEC POINTING CORRECTION (ARC MIN)
HOUR ANGLE
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-4.20
-1.40
1.40
4.20
7.00
90.00
63.00
36.00
9.00
-18.00
-45.00
MINIMUM= 8.65E+00 AT X= 0.00E+00
Y= 8.90E+01
T= 2.16E+01
0= 0.00E+00
MAXIMUM= 2.16E+01 AT X= 5.69E+00
Y= 3.00E+00

Figure 3.

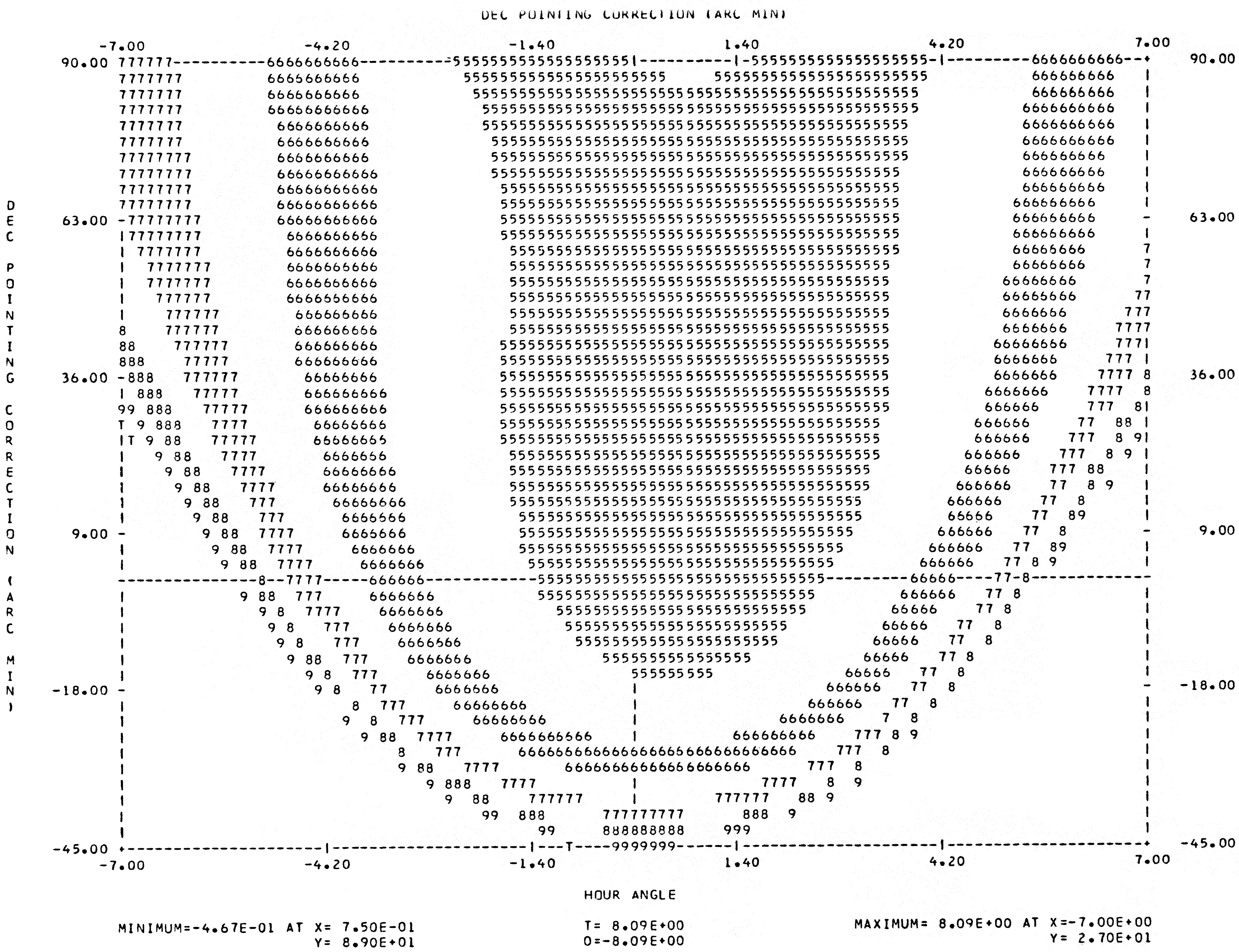

DEC POINTING CORRECTION (ARC MIN)
-7.00
-4.20
-1.40
1.40
4.20
7.00
90.00
63.00
36.00
9.00
-18.00
-45.00
DEC POINTING CORRECTION (ARC MIN)
HOUR ANGLE
MINIMUM=-4.67E-01 AT X= 7.50E-01
Y= 8.90E+01
T= 8.09E+00
0=-8.09E+00
MAXIMUM= 8.09E+00 AT X=-7.00E+00
Y= 2.70E+01

Figure 4.

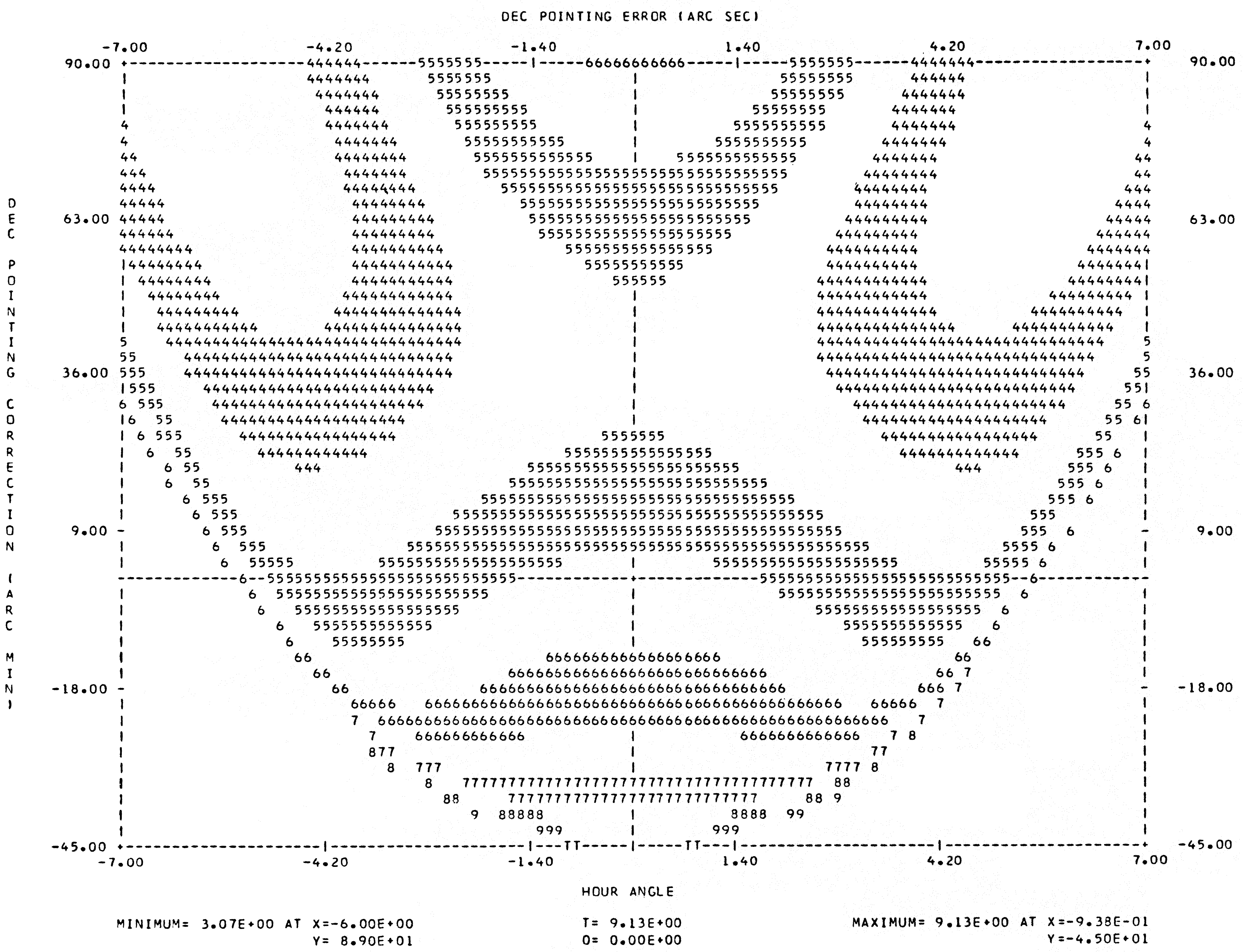
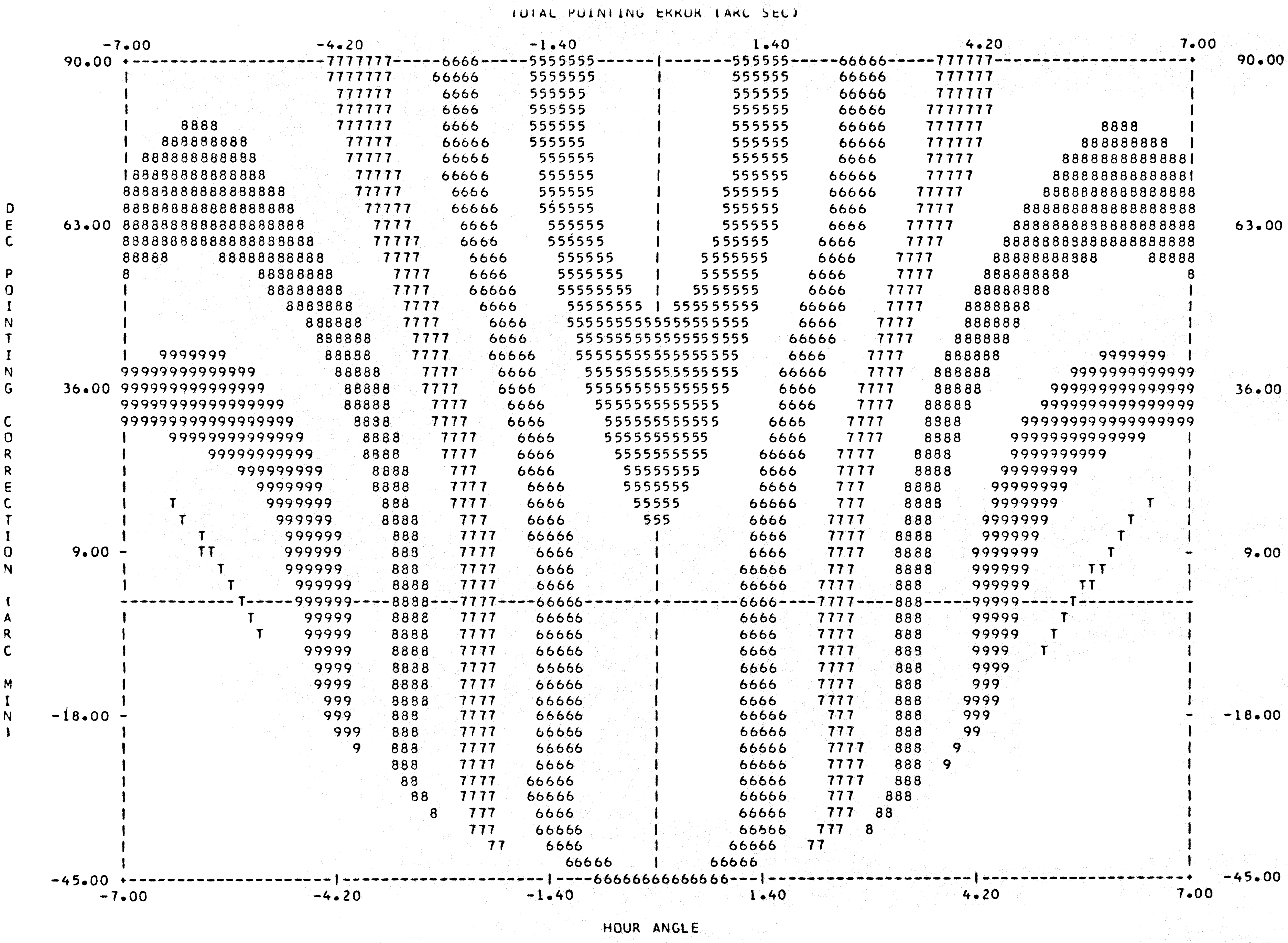

DEC POINTING ERROR (ARC SEC)
-7.00
-4.20
-1.40
1.40
4.20
7.00
90.00
63.00
36.00
9.00
-18.00
-45.00
DEC POINTING CORRECTION (ARC MIN)
HOUR ANGLE
MINIMUM= 3.07E+00 AT X=-6.00E+00
Y= 8.90E+01
T= 9.13E+00
0= 0.00E+00
MAXIMUM= 9.13E+00 AT X=-9.38E-01
Y=-4.50E+01

Figure 5.

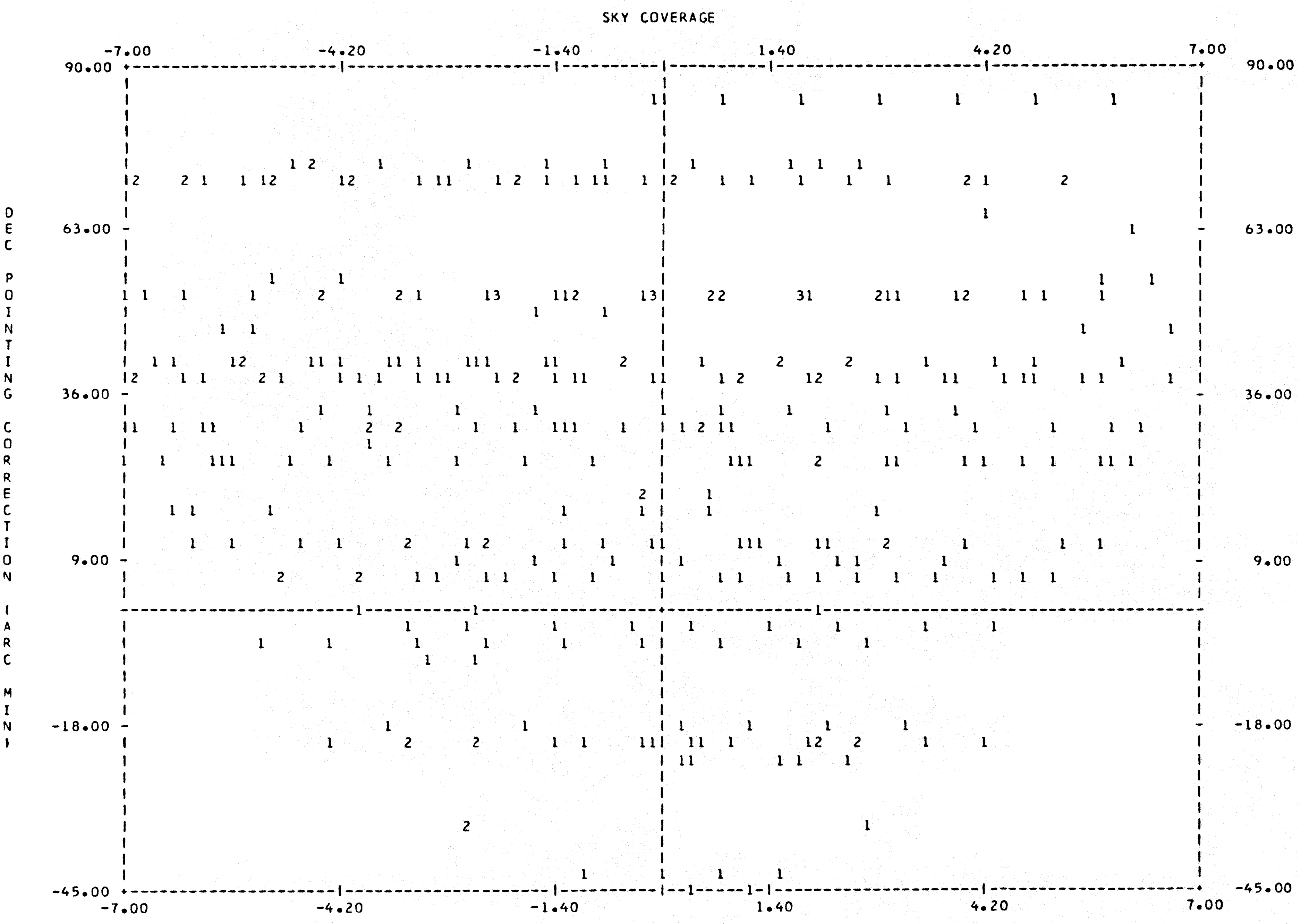


MINIMUM= 1.01E+01 AT X= 0.00E+00
Y= 7.90E+01

T= 2.25E+01
O= 0.00E+00

MAXIMUM= 2.25E+01 AT X= 5.69E+00
Y= 3.00E+00

Figure 6.

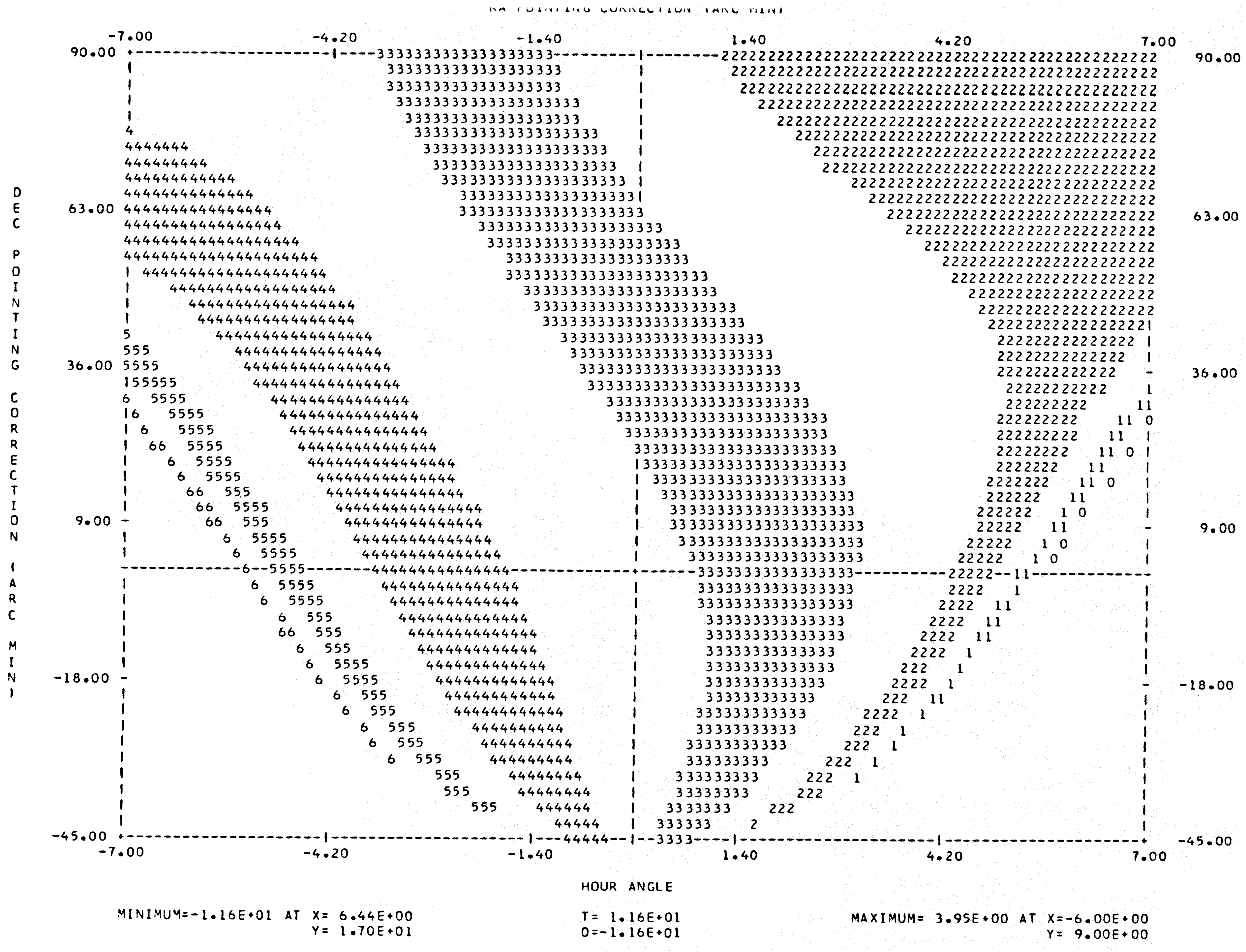


MINIMUM= 0.00E+00 AT X= 0.00E+00
Y= 0.00E+00

T= 1.00E+01
0= 0.00E+00

MAXIMUM= 0.00E+00 AT X= 0.00E+00
Y= 0.00E+00

Figure 7.


DEC POINTING CORRECTION (ARC MIN)
HOUR ANGLE
-7.00
-4.20
-1.40
1.40
4.20
7.00
90.00
63.00
36.00
9.00
-18.00
-45.00
MINIMUM=-1.16E+01 AT X= 6.44E+00
Y= 1.70E+01
T= 1.16E+01
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MAXIMUM= 3.95E+00 AT X=-6.00E+00
Y= 9.00E+00

Figure 8.

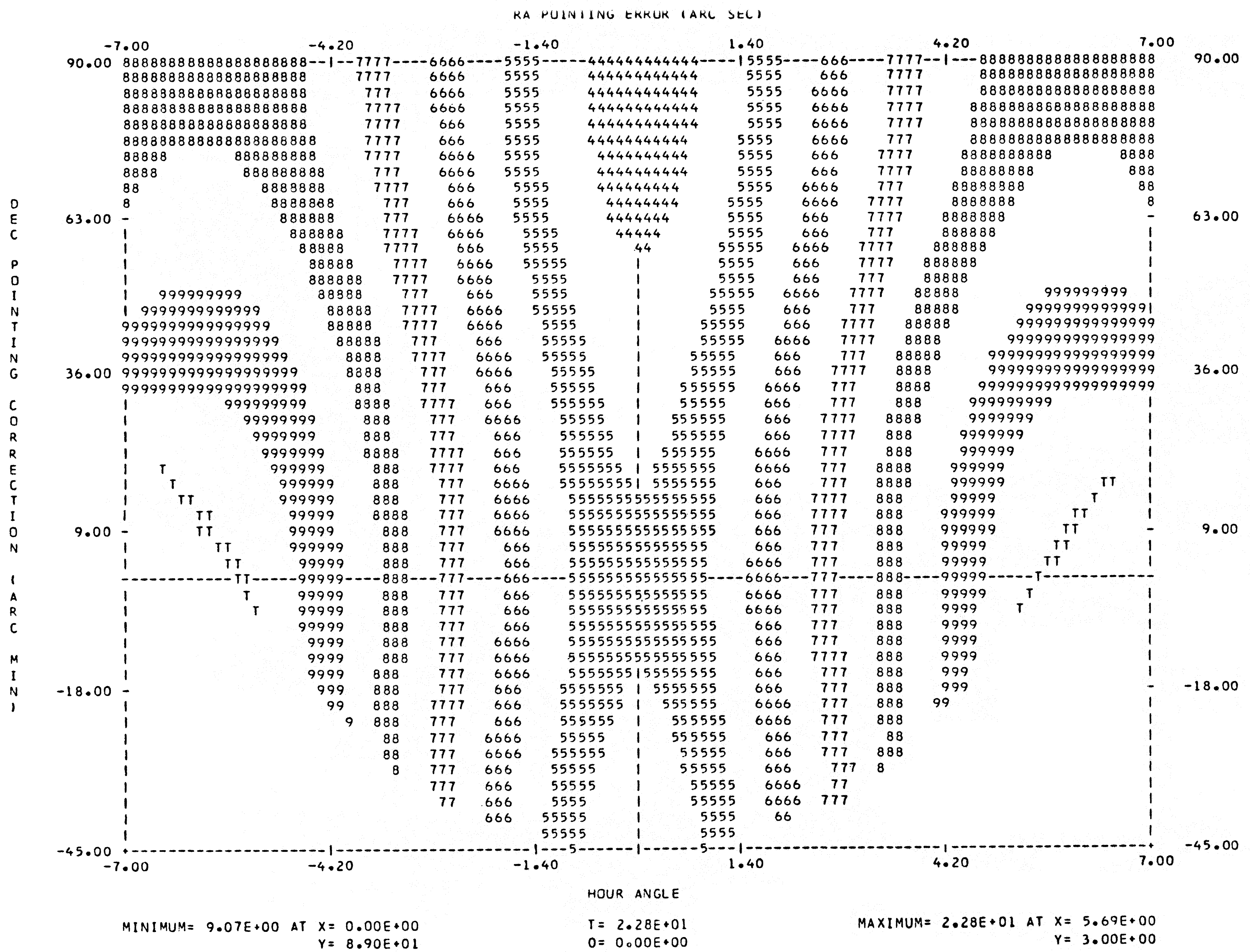
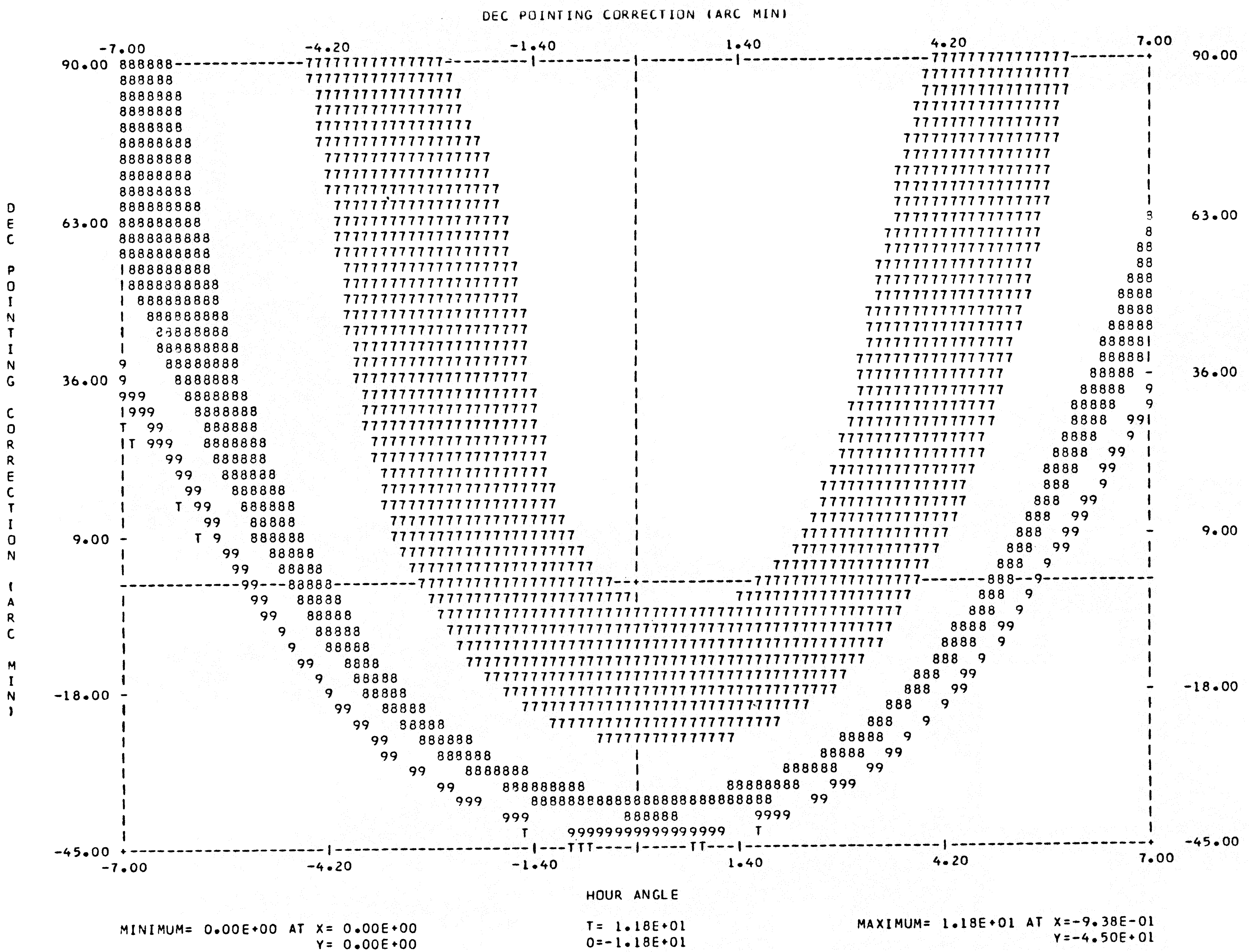

RA POINTING ERROR (ARC SEC)
DEC POINTING CORRECTION (ARC MIN)
-7.00
-4.20
-1.40
1.40
4.20
7.00
90.00
63.00
36.00
9.00
-18.00
-45.00
HOUR ANGLE
MINIMUM= 9.07E+00 AT X= 0.00E+00
Y= 8.90E+01
T= 2.28E+01
0= 0.00E+00
MAXIMUM= 2.28E+01 AT X= 5.69E+00
Y= 3.00E+00

Figure 9.



DEC POINTING CORRECTION (ARC MIN)
-7.00
-4.20
-1.40
1.40
4.20
7.00
90.00
63.00
36.00
9.00
-18.00
-45.00
HOUR ANGLE
MINIMUM= 0.00E+00 AT X= 0.00E+00
Y= 0.00E+00
T= 1.18E+01
0=-1.18E+01
MAXIMUM= 1.18E+01 AT X=-9.38E-01
Y=-4.50E+01

Figure 10.

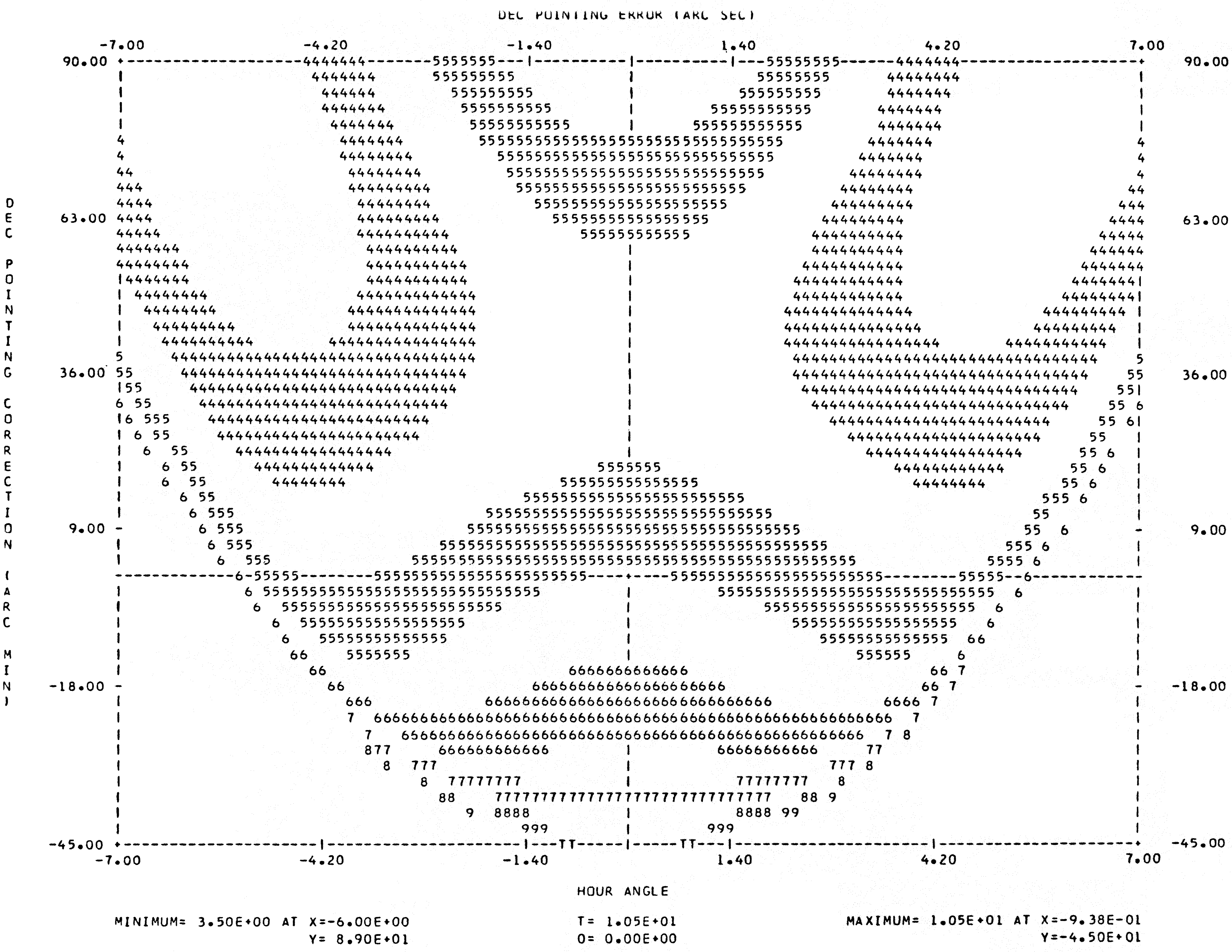
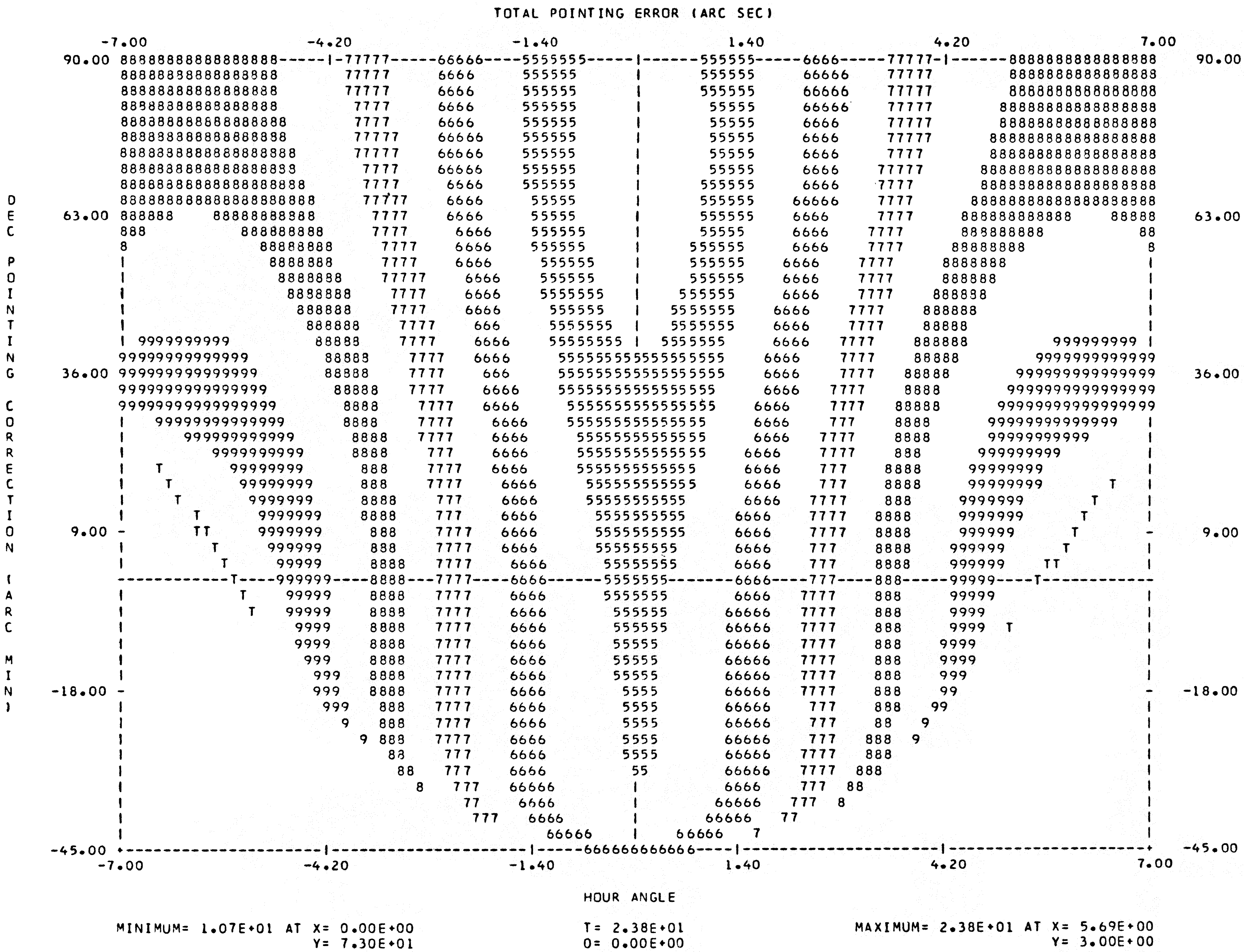

DEC POINTING ERROR (ARC SEC)
DEC POINTING CORRECTION (ARC MIN)
HOUR ANGLE
-7.00
-4.20
-1.40
1.40
4.20
7.00
90.00
63.00
36.00
9.00
-18.00
-45.00
MINIMUM= 3.50E+00 AT X=-6.00E+00
Y= 8.90E+01
T= 1.05E+01
0= 0.00E+00
MAXIMUM= 1.05E+01 AT X=-9.38E-01
Y=-4.50E+01

Figure 11


TOTAL POINTING ERROR (ARC SEC)
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-4.20
-1.40
1.40
4.20
7.00
90.00
63.00
36.00
9.00
-18.00
-45.00
DEC POINTING CORRECTION (ARC MIN)
HOUR ANGLE
MINIMUM= 1.07E+01 AT X= 0.00E+00
Y= 7.30E+01
T= 2.38E+01
0= 0.00E+00
MAXIMUM= 2.38E+01 AT X= 5.69E+00
Y= 3.00E+00

Figure 12.

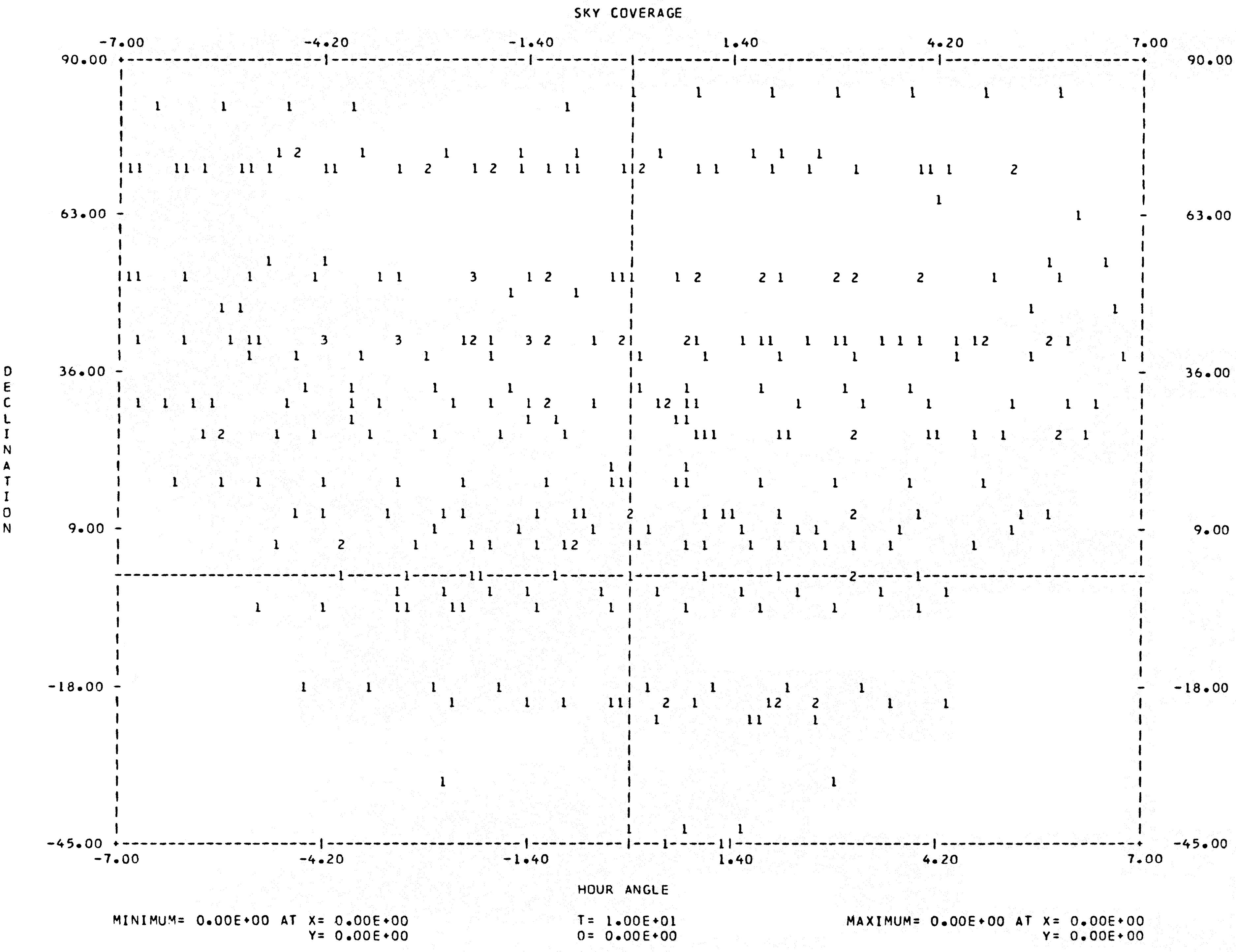
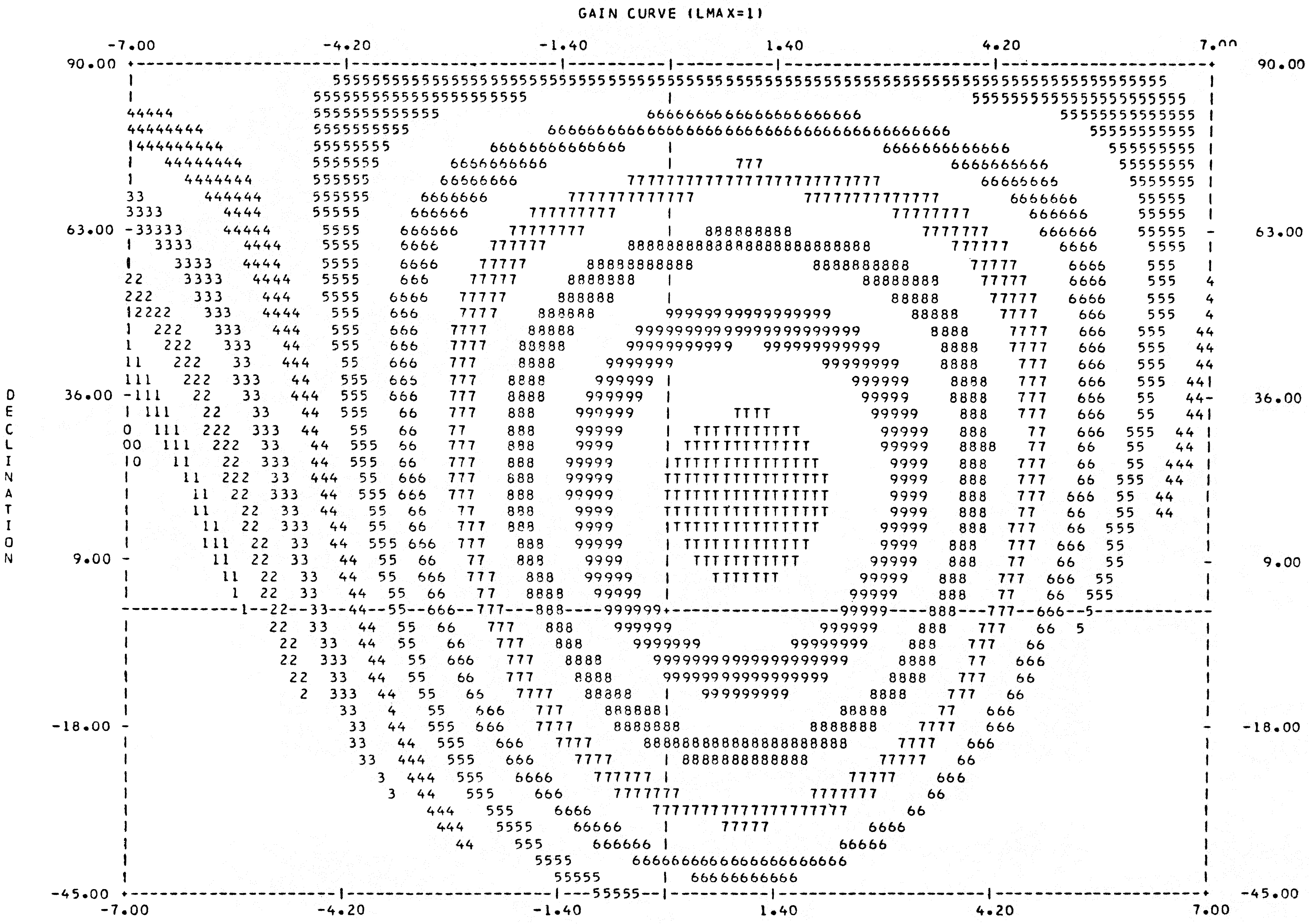

SKY COVERAGE
HOUR ANGLE
DECLINATION
-7.00
-4.20
-1.40
1.40
4.20
7.00
90.00
63.00
36.00
9.00
-18.00
-45.00
MINIMUM= 0.00E+00 AT X= 0.00E+00
Y= 0.00E+00
T= 1.00E+01
O= 0.00E+00
MAXIMUM= 0.00E+00 AT X= 0.00E+00
Y= 0.00E+00

Figure 13.



MINIMUM= 1.85E-01 AT X=-7.00E+00
Y= 2.70E+01

T= 2.09E-01
0= 1.85E-01

MAXIMUM= 2.09E-01 AT X= 1.00E+00
Y= 1.90E+01

Figure 14.

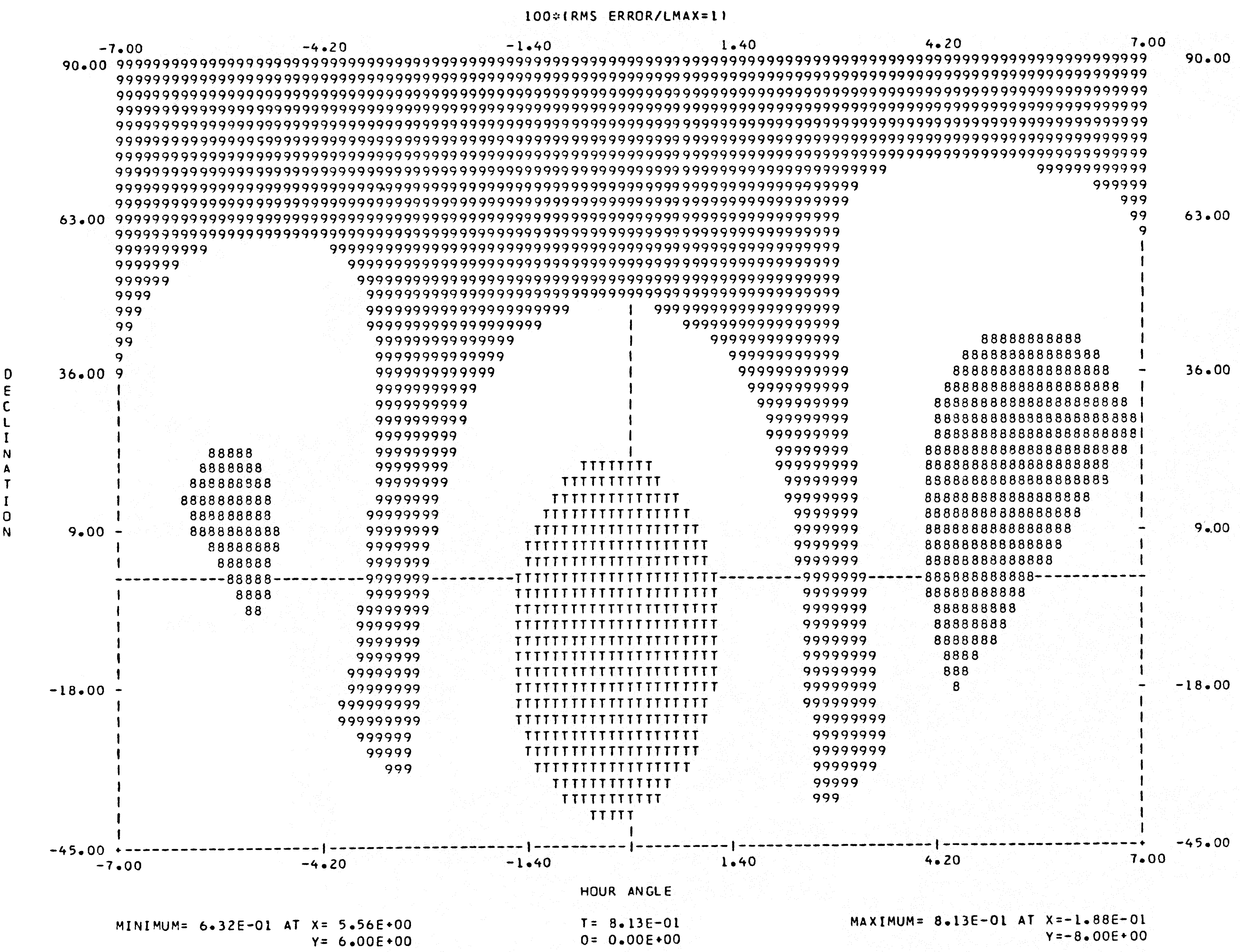

100*(RMS ERROR/LMAX=1)
-7.00
-4.20
-1.40
1.40
4.20
7.00
90.00
63.00
36.00
9.00
-18.00
-45.00
DECLINATION
HOUR ANGLE
MINIMUM= 6.32E-01 AT X= 5.56E+00
Y= 6.00E+00
T= 8.13E-01
0= 0.00E+00
MAXIMUM= 8.13E-01 AT X=-1.88E-01
Y=-8.00E+00

Figure 15.

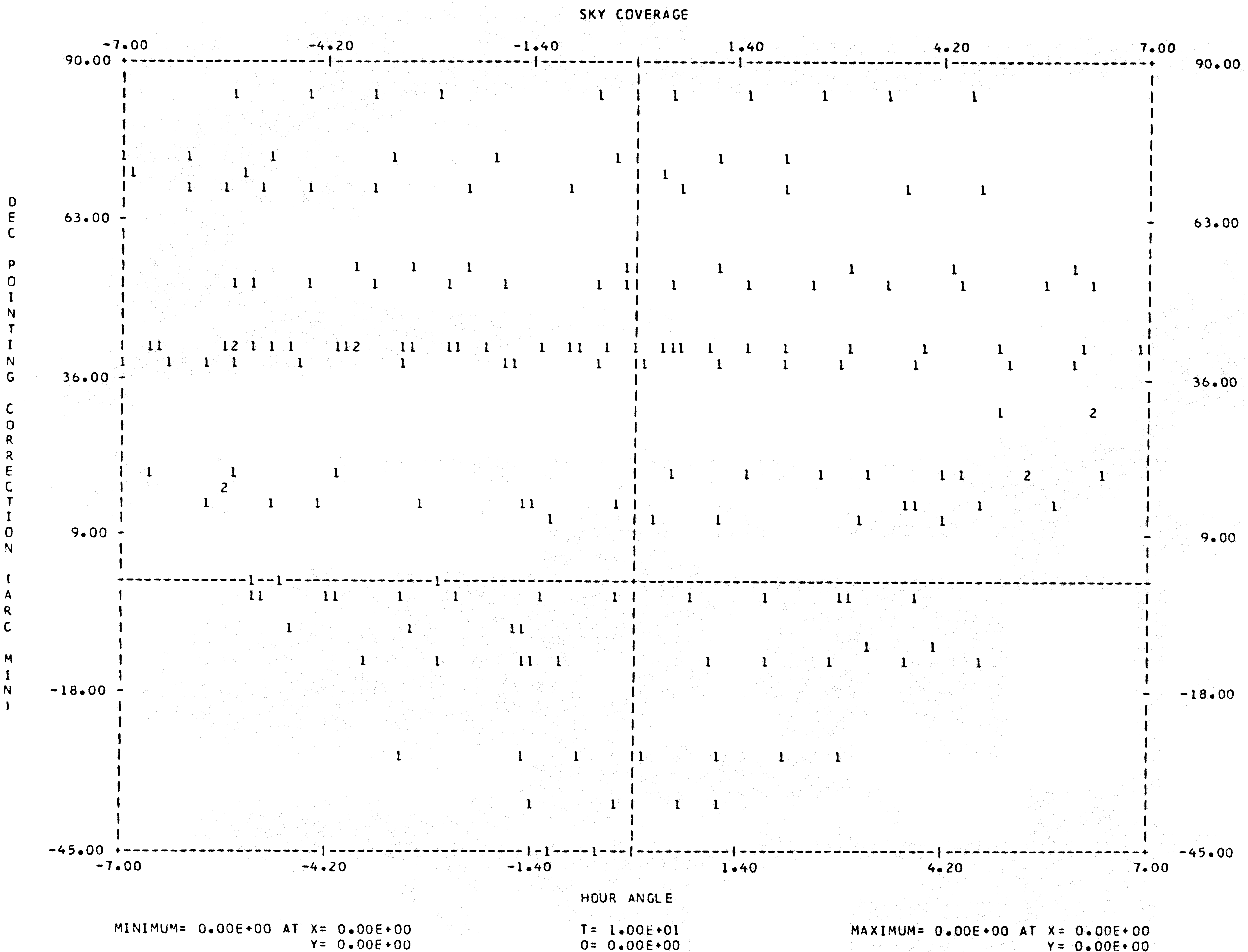
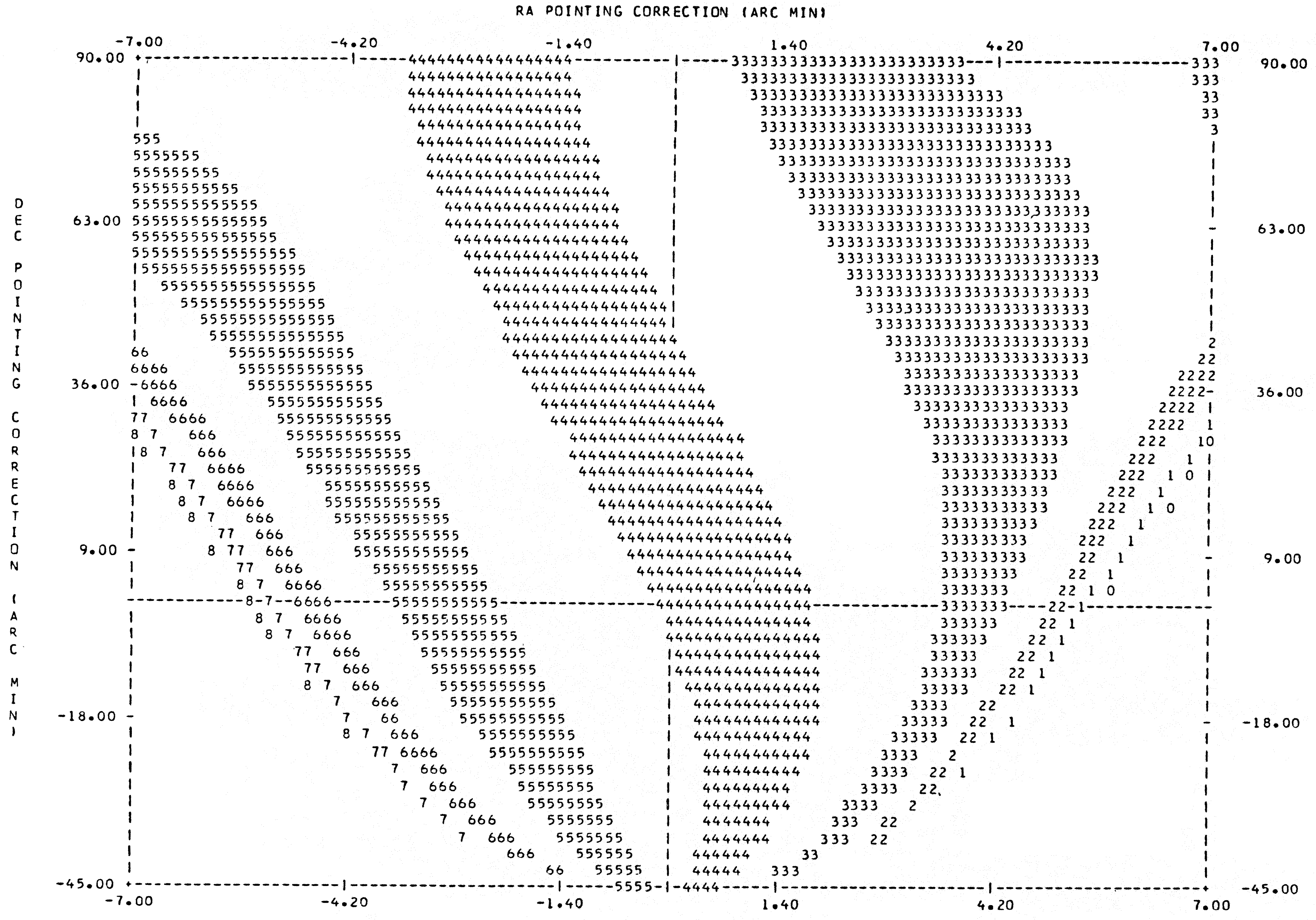

SKY COVERAGE
-7.00
-4.20
-1.40
1.40
4.20
7.00
90.00
63.00
36.00
9.00
-18.00
-45.00
DEC POINTING CORRECTION (ARC MIN)
HOUR ANGLE
MINIMUM= 0.00E+00 AT X= 0.00E+00
Y= 0.00E+00
T= 1.00E+01
0= 0.00E+00
MAXIMUM= 0.00E+00 AT X= 0.00E+00
Y= 0.00E+00

Figure 16



MINIMUM=-9.61E+00 AT X= 6.44E+00 Y= 1.70E+01

T= 9.61E+00 0=-9.61E+00

MAXIMUM= 6.22E+00 AT X=-6.00E+00 Y= 9.00E+00

Figure 17.

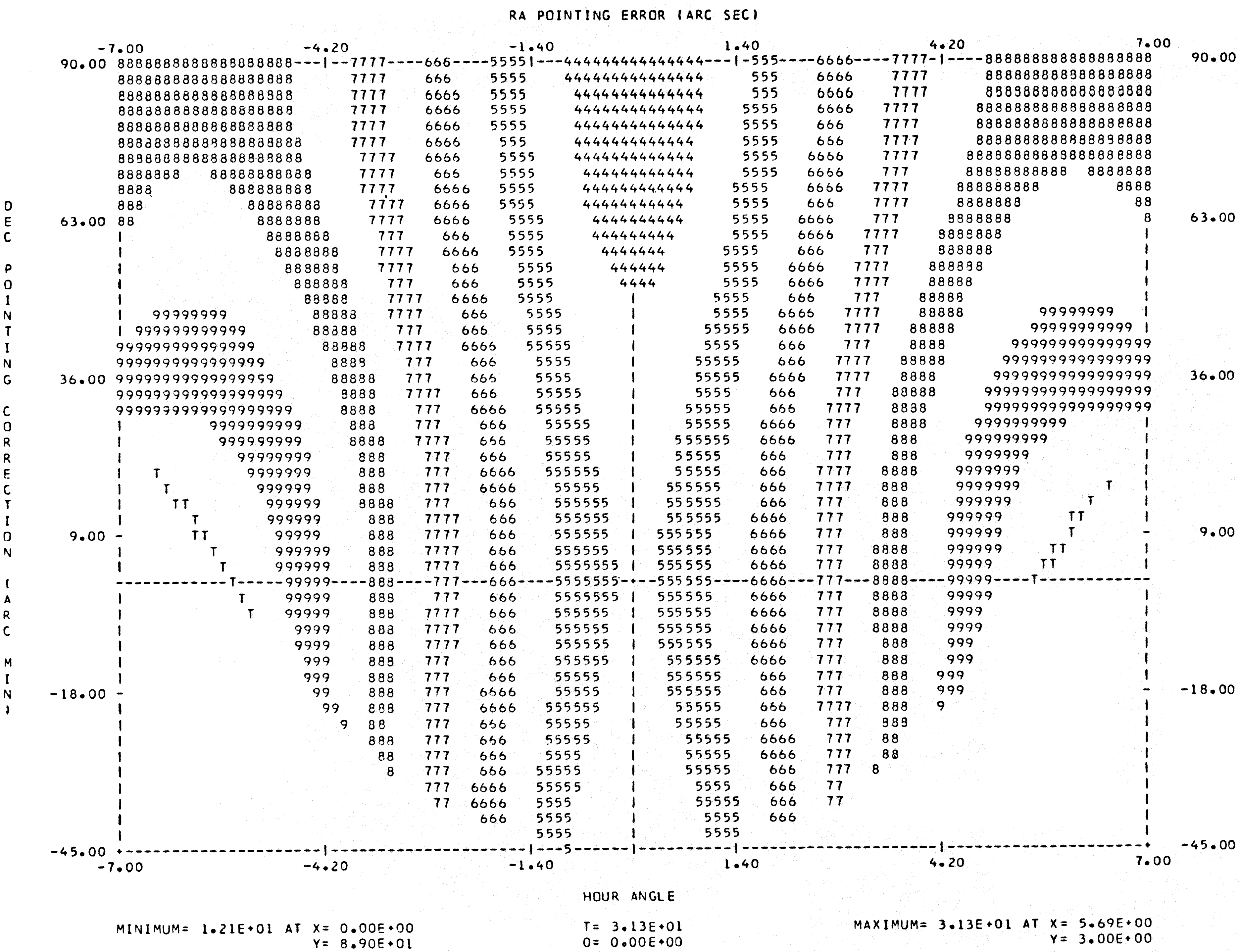
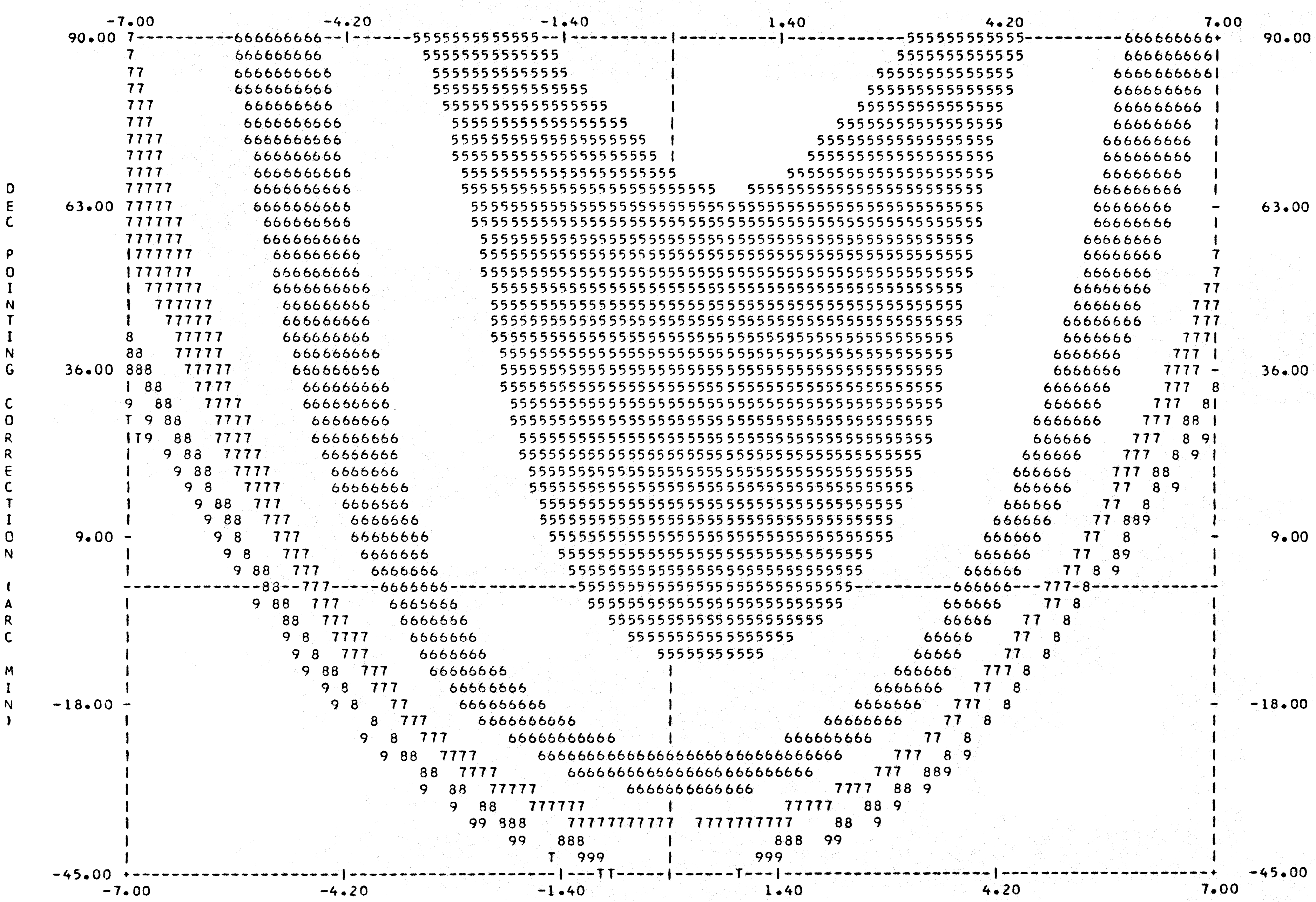

RA POINTING ERROR (ARC SEC)
DEC POINTING CORRECTION (ARC MIN)
HOUR ANGLE
-7.00
-4.20
-1.40
1.40
4.20
7.00
90.00
63.00
36.00
9.00
-18.00
-45.00
MINIMUM= 1.21E+01 AT X= 0.00E+00
Y= 8.90E+01
T= 3.13E+01
0= 0.00E+00
MAXIMUM= 3.13E+01 AT X= 5.69E+00
Y= 3.00E+00

Figure 18

DEC POINTING CORRECTION (ARC MIN)



MINIMUM=-8.62E-01 AT X= 6.25E-01
Y= 8.90E+01

T= 8.05E+00
0=-8.05E+00

MAXIMUM= 8.05E+00 AT X=-9.38E-01
Y=-4.50E+01

Figure 19.

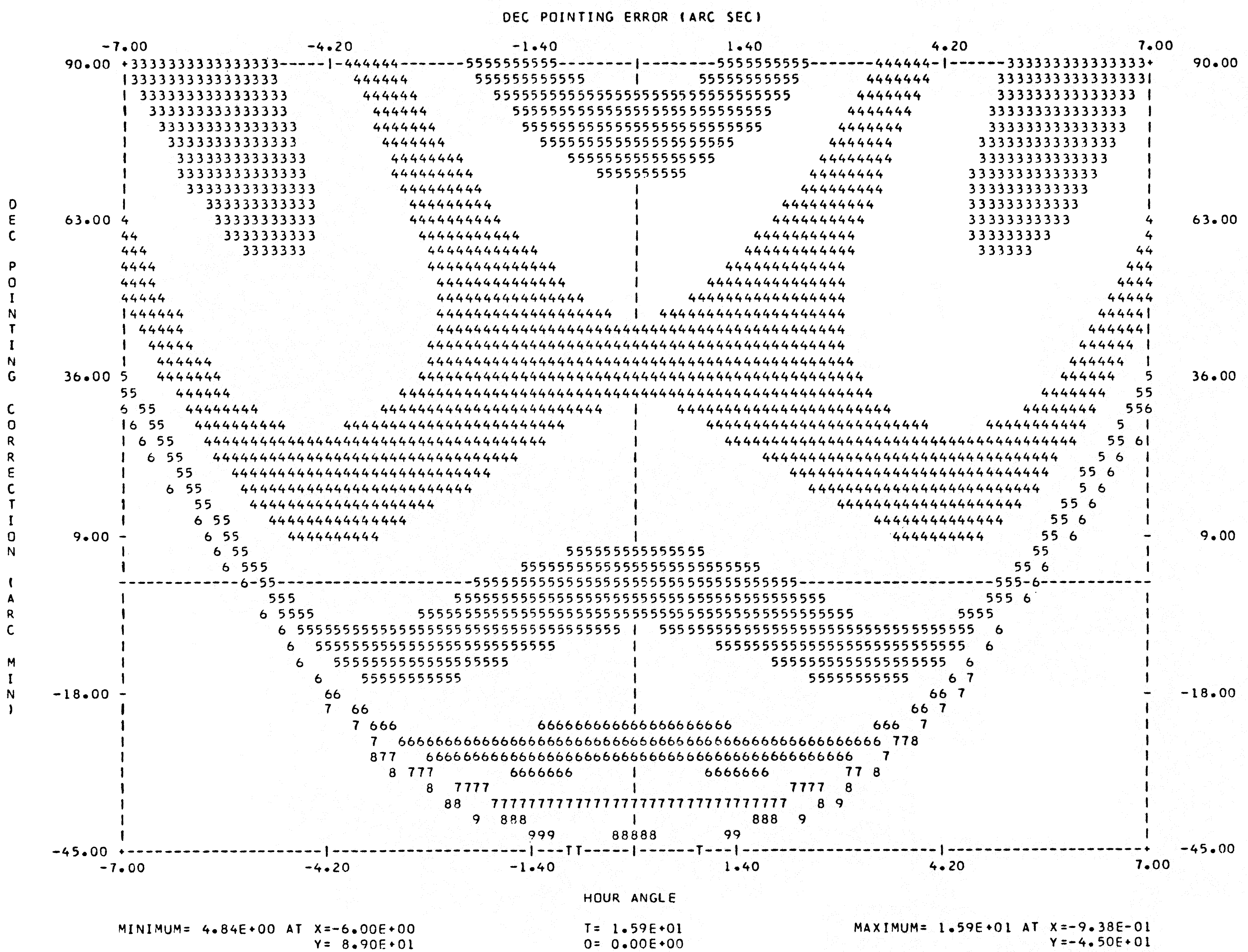

DEC POINTING ERROR (ARC SEC)
DEC POINTING CORRECTION (ARC MIN)
HOUR ANGLE
-7.00
-4.20
-1.40
1.40
4.20
7.00
90.00
63.00
36.00
9.00
-18.00
-45.00
MINIMUM= 4.84E+00 AT X=-6.00E+00
Y= 8.90E+01
T= 1.59E+01
0= 0.00E+00
MAXIMUM= 1.59E+01 AT X=-9.38E-01
Y=-4.50E+01

Figure 20.

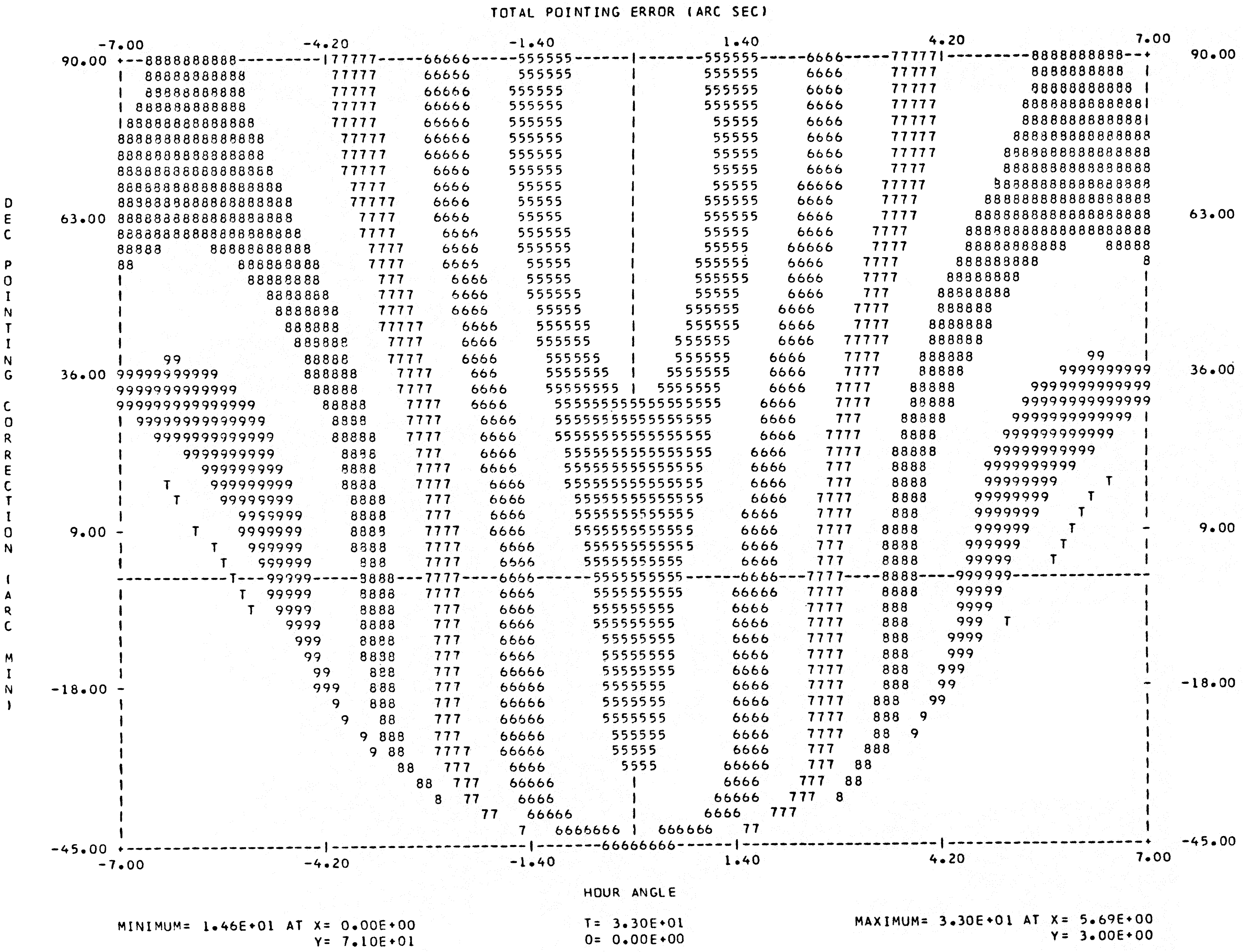
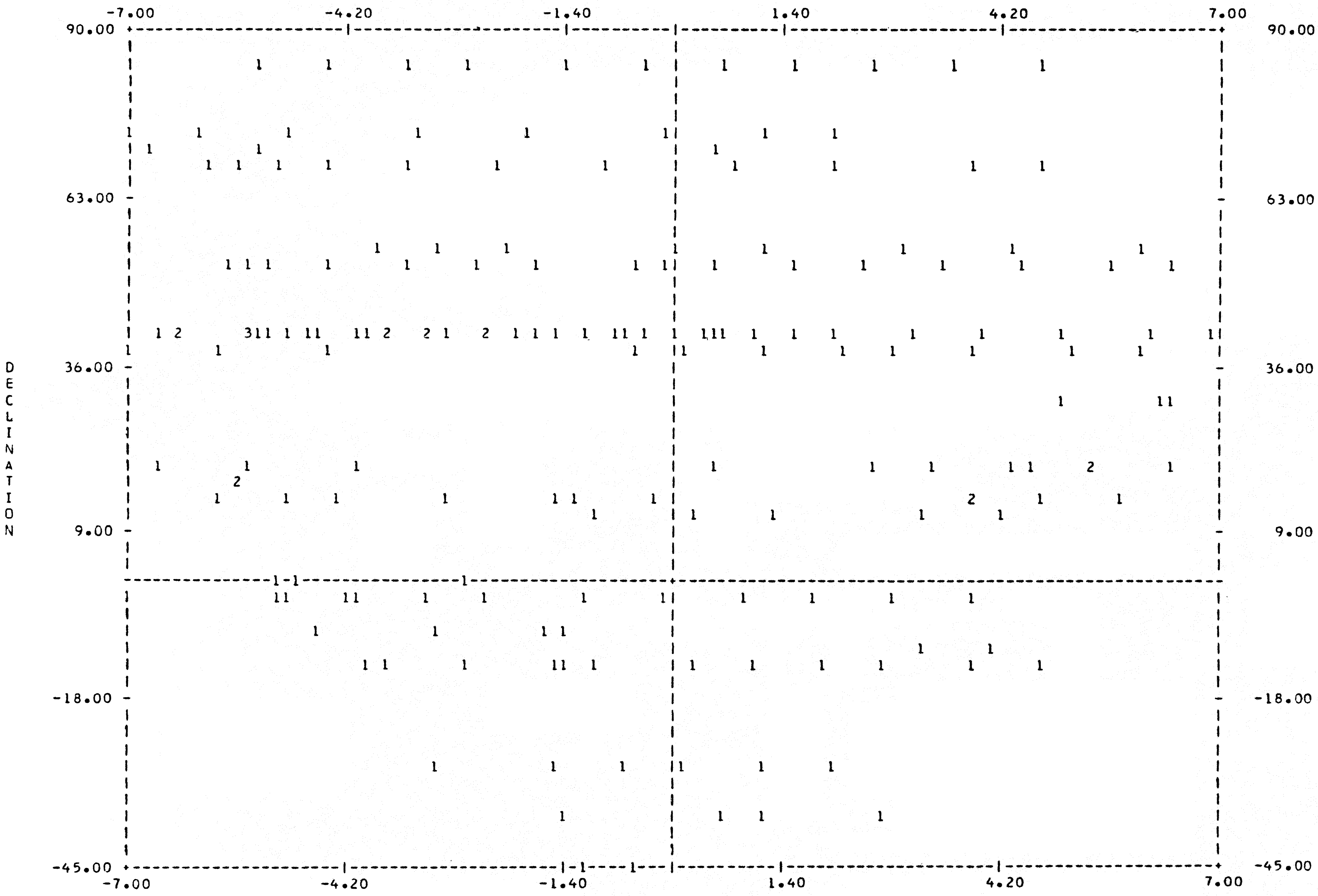

TOTAL POINTING ERROR (ARC SEC)
-7.00
-4.20
-1.40
1.40
4.20
7.00
90.00
63.00
36.00
9.00
-18.00
-45.00
DEC POINTING CORRECTION (ARC MIN)
HOUR ANGLE
MINIMUM= 1.46E+01 AT X= 0.00E+00
Y= 7.10E+01
T= 3.30E+01
0= 0.00E+00
MAXIMUM= 3.30E+01 AT X= 5.69E+00
Y= 3.00E+00

Figure 21.

SKY COVERAGE



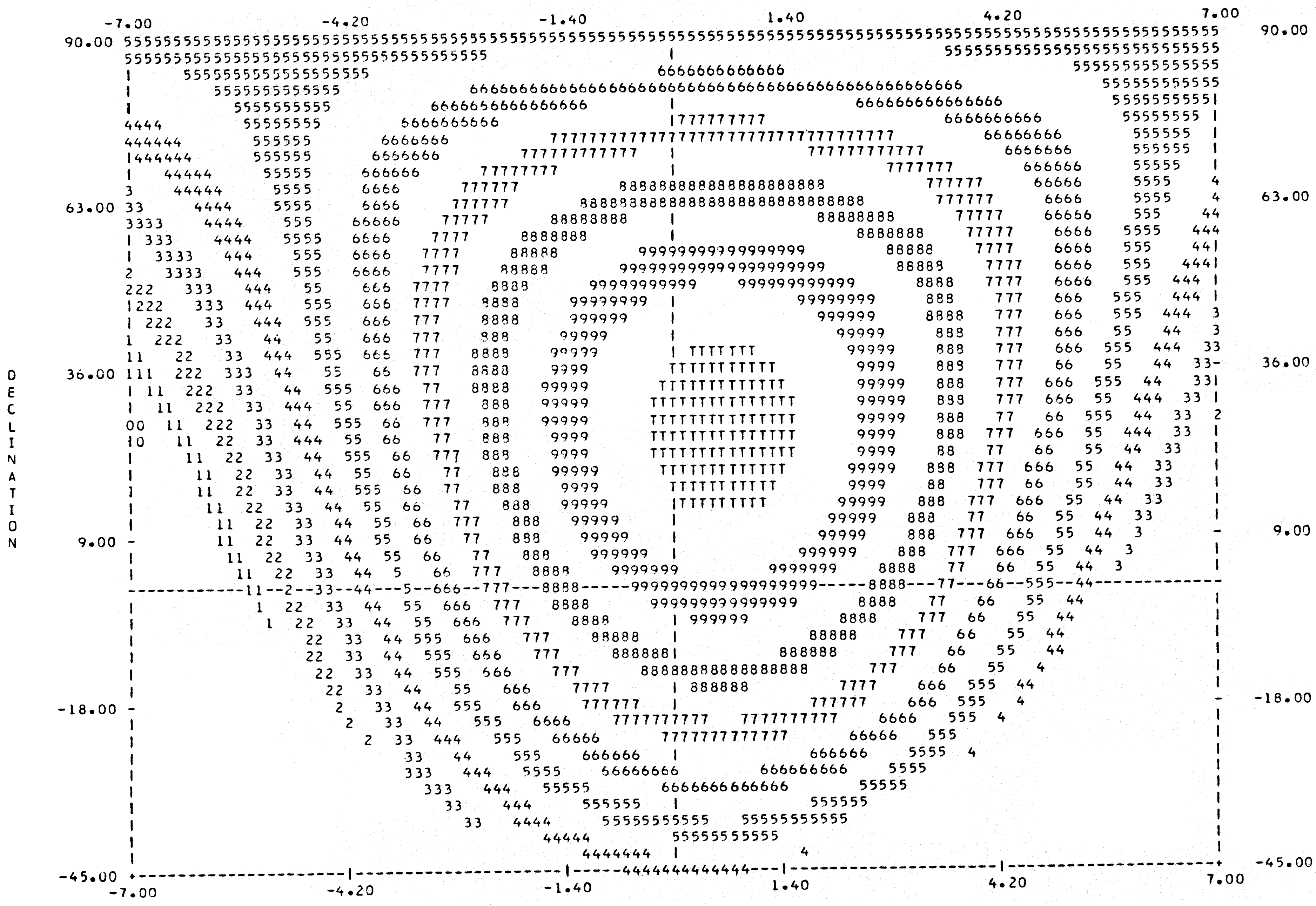
MINIMUM= 0.00E+00 AT X= 0.00E+00
Y= 0.00E+00

T= 1.00E+01
O= 0.00E+00

MAXIMUM= 0.00E+00 AT X= 0.00E+00
Y= 0.00E+00

Figure 22.

GAIN CURVE (LMAX=1)



MINIMUM= 1.62E-01 AT X=-7.00E+00
Y= 2.70E+01

T= 2.48E-01
0= 1.62E-01

MAXIMUM= 2.48E-01 AT X= 6.25E-01
Y= 2.50E+01

Figure 23.

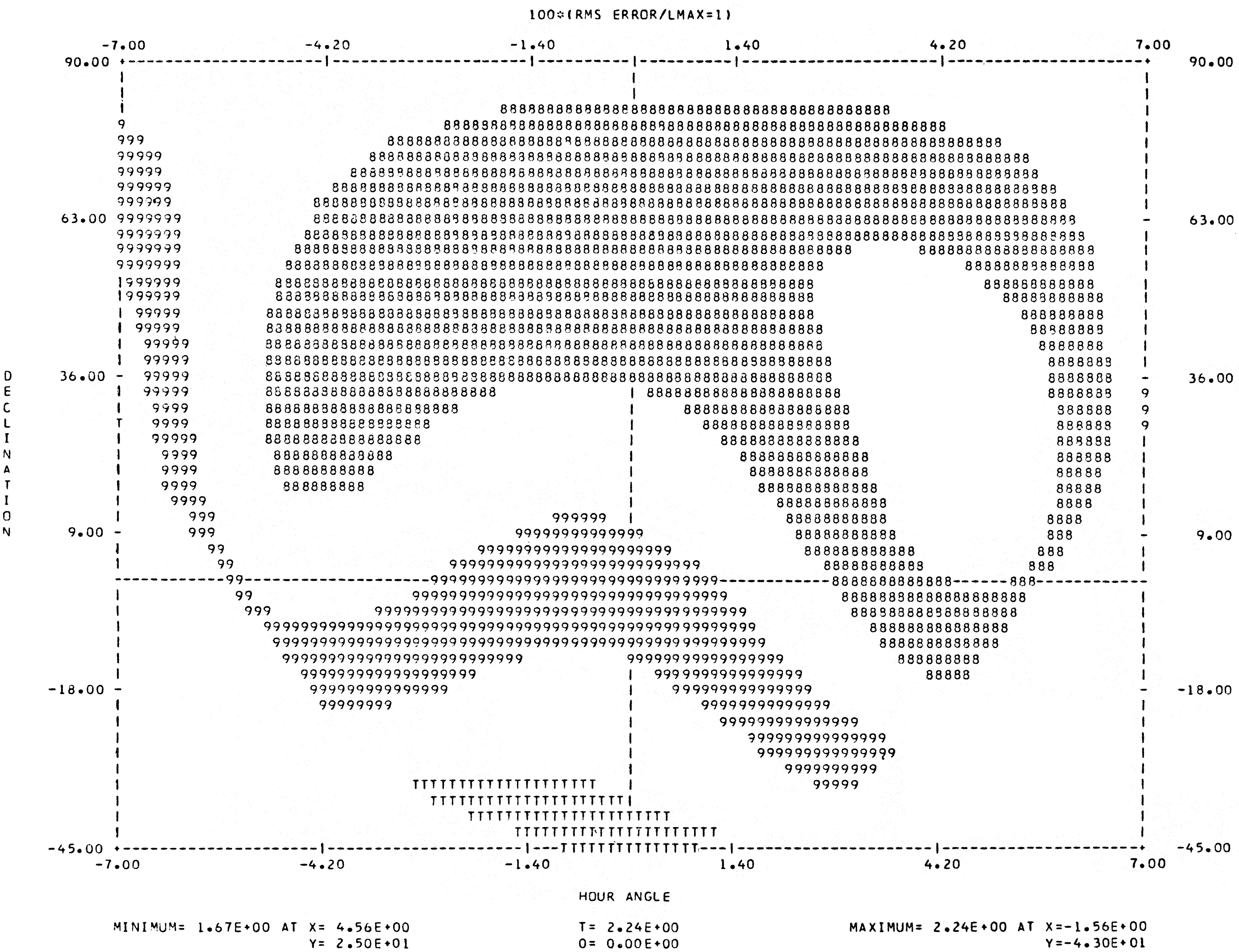
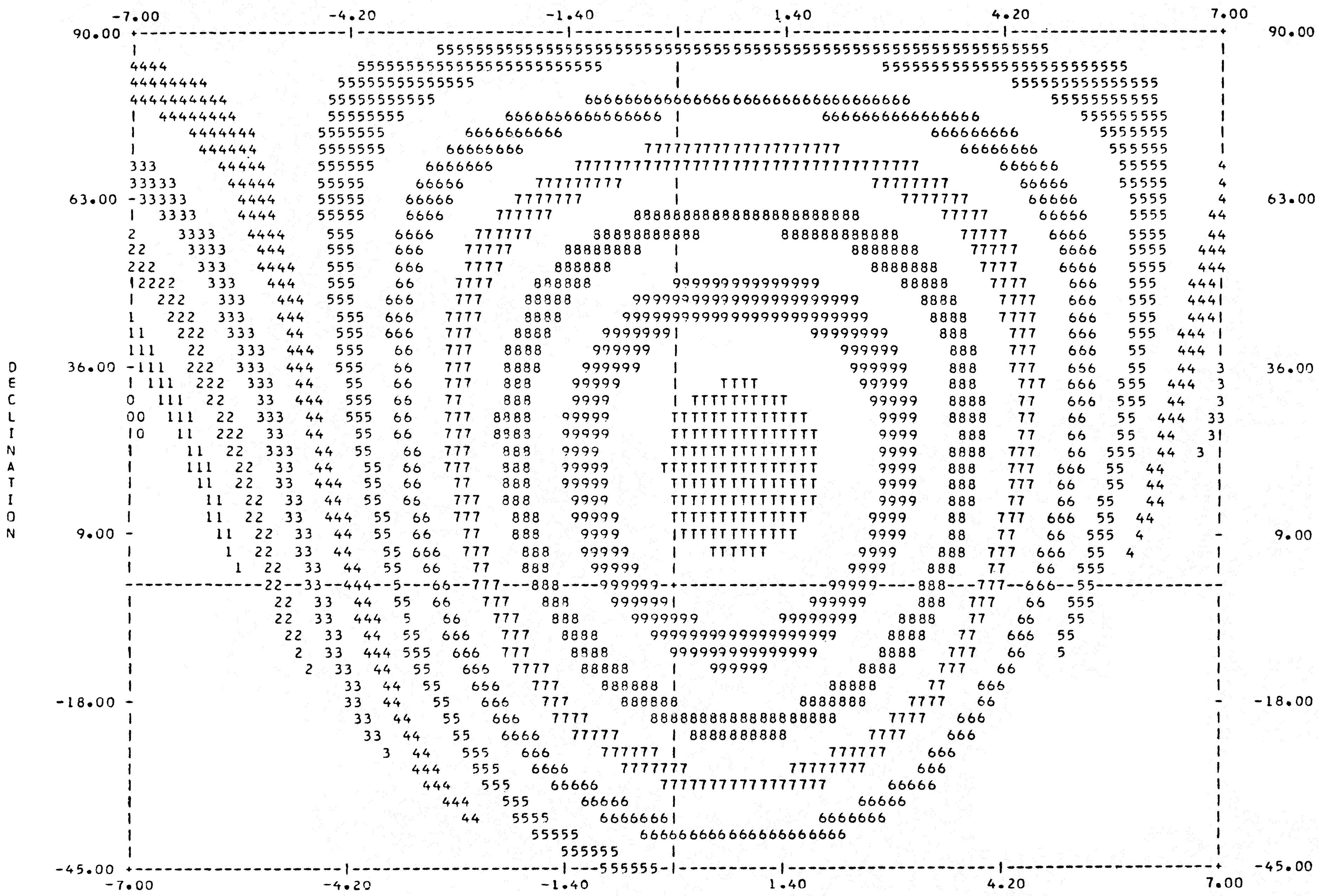

100*(RMS ERROR/LMAX=1)
DECLINATION
HOUR ANGLE
MINIMUM= 1.67E+00 AT X= 4.56E+00
Y= 2.50E+01
T= 2.24E+00
0= 0.00E+00
MAXIMUM= 2.24E+00 AT X=-1.56E+00
Y=-4.30E+01

Figure 24.

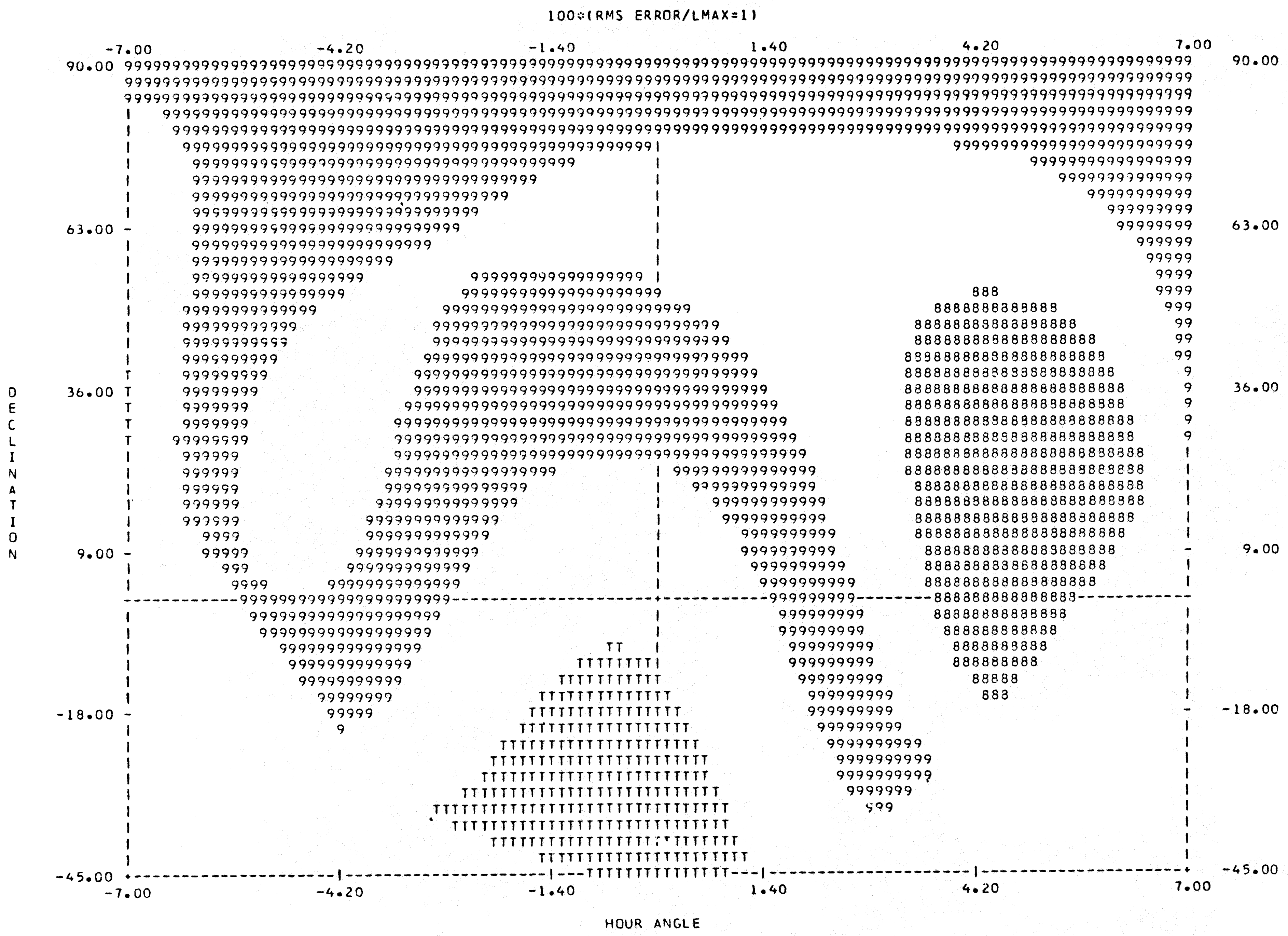
GAIN CURVE (LMAX=1)



MINIMUM= 1.79E-01 AT X=-7.00E+00
Y= 2.70E+01

T= 2.53E-01
0= 1.79E-01

MAXIMUM= 2.53E-01 AT X= 8.75E-01
Y= 1.90E+01



MINIMUM= 1.69E+00 AT X= 5.06E+00
Y= 1.10E+01

T= 2.18E+00
0= 0.00E+00

MAXIMUM= 2.18E+00 AT X=-1.06E+00
Y=-4.30E+01

Figure 26.